International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

EXAMINATION OF THE SKILLS FOR FACILITATING CNC THERMAL CUTTING OPERATIONS TO MEET THE INFRASTRUCTURE DEMAND IN INDIA

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DISSERTATION, Presented to the Swiss School of Business and Management Geneva, In Partial Fulfillment, Of the Requirements
For the Degree
DOCTOR OF BUSINESS ADMINISTRATION, SWISS SCHOOL OF BUSINESS AND MANAGEMENT GENEVA, 2024

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to Dr Prof Ljiljana.Kukec from the Swiss School of Business and Management, Geneva who has been my guide for this program. Her exceptional support and patience kept me motivated and taught me the finer aspects of academic excellence.
I would like to thank Upgrad for giving me the opportunity to pursue this program. I take this opportunity to thank my buddy Mr Sachin at Upgrade and their counsellors viz Ms GowriShankar & Ms Sujal Menon who were continuously in touch with me to meet deadlines. It will be unfair not to thank the industrialists, vocational institutes and workers who shared their views during our research survey.
My colleagues, superiors and support staff at my place of work spanning the last three decades deserve the credit for having sharpened my professional learning. Last but not the least, a special gratitude towards my family who supported my decision to pursue this program at this juncture of life when I've already had 36 years of work experience.

ABSTRACT

Specialized skills accompanied by the scale of execution decide the rate of national progress and future development, which will be continual and sustainable. In my 35 years of work experience, I had opportunity to interact with the finest of industry professionals, training institutes, employment agencies and technology drivers. A key area of progress, which relates directly towards meeting the national growth targets, is about processing of steel. Steel plays an important role in our day-to-day life. Starting from our basic day needs to building super structures, its steel everywhere. A close look at steel processing helps us identify the areas of attention required and possible steps towards addressing the same. Thermal cutting of steel, namely through gas, plasma and laser cutting forms backbone of the steel processing process. This gives us opportunity to study the challenges within and recommend steps to mitigate the same. The inauguration of the world's longest highway tunnel, the Atal Tunnel, and the construction of the world's highest railway bridge, the Chenab Bridge to name a few. India's

infrastructure sector is poised for unparalleled growth, driven by government initiatives .and increased investments. India is poised for strong growth in this area, with investments worth approximately US$1.4 trillion planned by 2025. Currently, the construction of national highways extended to approximately 12,000 kilometers, averaging about 30 kilometers per day. Studies indicate that there are several factors that contribute to poor or strong national infrastructure, and they include funds, provision of developmental resources and efficiency of labour as well as repair and maintenance. Our study identifies the national scenario with respect to available skills in the area of CNC thermal cutting. The study involved a detailed SWOT analysis, fundamental research and the analyzing the present scenario and implementation of essential steps for the future.

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CHAPTER 1
INTRODUCTION

Introduction

India stands proud, as the 3 rd largest producer of steel in the world today aggressively targeting exponential growth .This production momentum will help India to meet the envisioned level of over 550 million tonnes of production capacity within the next 3 decades. Steel will mainly get consumed towards national infrastructure building as shown in table 1, which includes;

Table 1: Infrastructural opportunities

Houses & Living Shelters	Airports	Power sector
Seaports	Supermarkets	Railways
Construction and mining equipment	Warehouses	High rises
Defence	Refineries	Roads
Bridges	Flyovers	Oil , Gas
Sports facilities	Shopfloors	Showrooms
Ship-buildng	Mining	Agro eqpt
Hospital's	Trauma centres	Aesthetics

Source : Author

This will require intensive steel processing. The infrastructure & construction industry consumes around 40-60 % of total steel produced (Irfan, Varadarajan, Mateen , Mobashir, Kumar & Shukla , 2023) . It is estimated that rural India steel consumption will double in next five to six years (Mohan , 2024) .

Production of steel will be followed by high volume steel processing which indirectly means adapting to newer technologies followed by installation of high tech machinery Steel has to be stored, handled , cut , rolled , bent , welded , machined and finished to be put into use for the above mentioned applications . These operations are carried out in fabrication workshops who employ skilled and unskilled manpower . As we add more high tech equipment, we have to add qualified human resources to meet production demands . Needless to say, the knowledge of process , programming skills management and cost control become very

essential to meet production targets and earn profits for the organization. Job rejections will have to be the lowest with the highest output. In today's scenario, there is mismatch between skills requirement of the industry vs skills imparted by traditional training schools. Skill development centres and initiatives are struggling to offer industry specific training.

Additionally, inadequate involvement of industry experts in the design and implementation of the training programmes accompanied by budget constraints act as potential hurdles. Low availability of skilled manpower is creating unanticipated problems.Unavoidable operations include Material handling, Thermal cutting, Welding, Grinding, Rolling, Machining etc. . . There are other operations like Polishing, Heat treatment, Shot Blasting, Painting, etc. that may also have to be carried out as per the production job guidelines. We have chosen CNC thermal cutting operation in steel fabrication as our focus to exemplify the objectives of this research mainly to; 1. Understand the present status of skill development in India 2. To understand the challenges in skill development in India.

Steel has to be cut to size and shape first and other operations follow it making CNC Thermal cutting of steel, the key operation that will decide the output from a workshop.

Preliminary Literature Review

Skill and employability are directly proportional. This paper reviews with a particular emphasis on the skills required by the manufacturing sector. Emerging technologies in manufacturing expose the present day work force to new environments. The challenge lies in training the work force in new technical and non-technical areas like teamwork, better communication and soft skills. It has been gestablished that this can affect an organization's productivity and return on investment [Charles R. Hulten].

An important study by Rothwell (2013) argues that there are actually two STEM [**Science, Technology, Engineering, and Mathematics Developments]** economies. One is a "professional" STEM economy associated with higher education and high levels of compensation and the other STEM economy "draws from high schools, workshops, vocational schools, and community colleges," and its members are "less likely to be directly involved in invention, but they are critical to the implementation of new ideas, and advise researchers on the feasibility of design options, cost estimates, and other practical aspects of technological development " by producing, installing, and repairing/trouble-shooting the machinery patented by professional researchers . In "Race against the Machine" Brynjolfsson and McAfee bring together a range of statistics, examples, and arguments to show that the average worker is not keeping up with cutting-edge technologies, and so is losing the race against the machine. The book makes the case that employment prospects are grim for many today not because there's been technology stagnation, but because we humans and our organizations aren't keeping up to changing scenarios and demands.

Available literature have limited specialized insight into examination of skills required in the specialized area of CNC Thermal cutting in steel fabrication. It's essential to have strong educational system—one that provides a full range of skill development.

In our view, these are the key areas that require attention which are knowledge of elementary mathematics ,process knowledge, simple programing skills and CAD, teamworking , ability to follow instructions and understand production schedule , planning and resource

management and maintenance skills . India is uniquely positioned in world due to its large employable work-force with over 60 to 65 % of population below 35 to 40 years as compared to developed countries whose population is aging . An employable population is a “double-edge sword ”. We can harness their potential and meet our ambitions or turn them into a huge liability for the nation leading to crime and lawlessness. Another major challenge in the Indian scenario is the gender discrimination which women opting for or not preferred for engineering based work.

Across the world, there are more men who are active in science, technology, engineering and medicine (STEM) than women (Balasubramanian , 2020) .

We would be referring to the present initiatives taken by Government of India as well as private organisations to elaborate our objectives therein . Additionally , its important to note that organisations have two types of customers , namely the internal and external customers (Duncan , 2024). Where a lot of effort is being put to capture and retain external customers , there is a strong requirement to retain and nurture the employees (internal customers) . During the course of examining skills needed in the field of CNC thermal cutting we will try and establish the peripheral skills required to make the job more satisfying and organisational inputs which can supplement the said purpose.

Discussion

Industrial output can be techno-commercially managed efficiently by balancing capital and labour. Powerful technological and global forces continue to shape the world of work, and one can only guess where they will lead as per the “Race against the Machine” of Brynjolfsson and McAfee (2014). In the future, automation will make most human work skills obsolete and create new jobs or challenges.

As Levy and Murnane (2013, 5) put it: “For the foreseeable future, the challenge of “Cybernation ”, is not mass unemployment but the need to educate many more young people for the jobs computers cannot do. ” (Cybernation here refers to concepts like auto-pilot in planes.)

Research methodology in our case covers ;

1. Interviews with top management among Steel fabricators, Vocational schools and Equipment manufacturers.
2. Survey questionarre feedback form line personnel in Steel fabrication, eqpt manufacture ring and vocational schools
3. Research the available published data on this subject.

The estimated period is December 2022 and May 2023.

Conclusion

Skill pool availability directly affects the economic growth of a nation. We have chosen to examine the same with respect to CNC thermal cutting process in steel fabrication as our focus for this research.

With this research we intend to demonstrate that :

1. Conclusive results can be reached for creating a road-map to meet future demand and also encourage further specific research to address gaps between industry and institution.

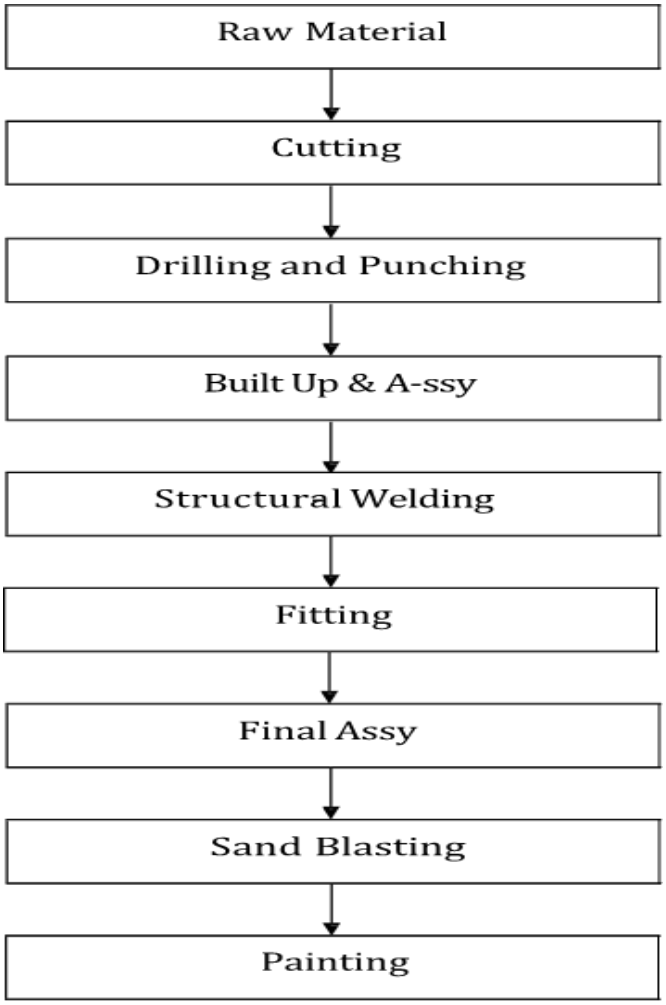
2. A continuously flowing talent pool can be created which will churn out " industry ready " candidates .

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This study is aimed at focusing on skills required for CNC thermal cutting operations to meet the growing infrastructure demand in India. Those who can study , use, and maintain these machines and software packages, are pivotal for the economic growth of the country(Kuna , Haskova , Haller 2021). We propose our study based on our experience as well as local and international researched data available in this regard . Infrastructural based manufacturing ref fig 2.1, broadly comprises of the steps mentioned therein (Willar , Waney , Senduk , 2018) .

Fig 2.1 Process flow



Source: DAS offshore

Our study is supported by three very important factors namely, skills available ,scale of operations and policies which are investor friendly , enabling competitiveness and supported by a strong regulatory framework (Roy ,2023). Our educational degrees alone are not

sufficient to ensure long term employability and productiveness *. The focus here is on a strong foundation. Stronger the foundation, longer you sustain.

We are the fifth largest GDP in the world (approximately US $ 4 Trillion)with a purchasing power parity at third position globally . As per the World Economic Forum, of the 13 million people who join India's workforce each year, only one in four management professionals, one in five engineers, and one in 10 graduates are employable. The Indian workforce can be summarised as young , low on skills and mostly present in the informal economic sector (Saran and Sharan , 2018). 50 % of Indian population is below 15 – 24 yrs age group causing a " youth bulge " (Savitri , Maurya , Haque , Verma , Singh , Kushwaha , Sokhi , 2022) .As per CMIE (Centre for monitoring Indian economy)at present approximately 40 % percent of the Indian youth are at the employable age (less than 25 years) and out of them , 49 % are unemployed as per their research in 2022. Though we have a young workforce , we find that only 2 to 3 % of employable population has undergone any form of formal vocational training (Sharma and Nagendra , 2016) .

The Indian situation is unique and requires seperate examination and analysis . Its impossible to straightaway implement tools and models that have succeeded in other economies. Empirical studies and programs failed to envisage the present economic scenario thus ,leading to demand -supply gaps. For example , you may produce 10000 cars a day but do you have sufficient road networks to use them ? Our examination of processing steel as a basic requirement to propel infrastructural growth linking it to manpower related skills arises as a major step to mitigate the fundamental challenges. Steel and other metals can be mass produced through a continuous process or even imported however, processing the same to meet the growing national demand is a challenge. CNC thermal cutting of various metals is the most important and a pivotal operation.

Our purpose is to identify the demand-supply gap and explore solutions to bridge the same.

2.2 Theory of reasoned action

In the fifties , Ho Chi Minh said "To reap a return in 10 years, plant trees. To reap a return in 100, cultivate the people ".

Traditional beliefs consider employment as a long-term association between an employer and the employee. People joined organizations, secured pay hikes and promotions. Some employees got different opportunities via job rotation policies. Some employees remained in the same department throughout their employment tenure. This is today challenged by environmental changes such as wars, industrial revolutions, growing demand, technology advancement, increased materialism, failure of traditional socialist models etc. Employers have to also deal with attrition. "Attrition is said to be the reduction in employee numbers when they retire , resign or die (Latha , 2013) .The gap between demand and supply is short , with one man expected to perform a task which was performed by multiple people in the past. Time available is not unlimited & technology is changing. The daily challenge is to perform under these circumstances, adapt to change, create wealth and prosperity. Skill plays the most important role in today's circumstances. Multiple skills are the prime strengths for a longer employable quotient or even a success in entrepreneurship. There is a uniform shift in (Bhattacharya, Bhandari, Bairagya 2020) employment from low- skilled occupations to high-

skilled occupations as a whole over time however ,this shift in employment is not uniform across all the sectors at the disaggregated level.

The paper points to the need for sector-specific policies based on changes in demand for different skills across sectors and attempts to motivate policymakers towards boosting key sectors for enhancing employment with varying skills. Production oriented jobs demanded higher skill requirements; clerical ones were simplified using more office automation. Shifts in the composition of the work force toward higher-skill production jobs contribute a smaller amount to the overall rise in average skill requirements (Cappelli 1993).

Interviews with a small group of machinists experienced in both conventional and CNC machines suggest that important factors determine whether the introduction of CNC machining leads to a change in overall skill level or in the skill mix (Zicklin 1987).

CNC Thermal cutting can be classified (Machine mfg 2023) as under based on volumes, precision and grade of material ;

- **CNC Oxyfuel cutting for carbon steels and titanium**
- **CNC Plasma cutting for carbon steels, stainless steels and aluminum . [Plasma can cut any metal]**
- **CNC Laser cutting of all metals**

Oxyfuel cutting is a very old process, over a 100 yrs. old (Messer Cutting systems 1898) commonly used in all workshops for cutting standard carbon steels (Mild steel) & Titanium. Mostly unskilled operators use this eqpt and investment is low . The advantage is that the cutting thicknesses of jobs is not a major constraint. This is classified as a chemical exothermic reaction which burns the metal and that's how cutting happens. One cannot cut stainless steel and non-ferrous metals by this process. The plasma cutting process was introduced in the sixties for cutting stainless steels and other metals. Being an electrophysical process, it can cut any conducting material, meaning all metals. The process was refined to cut carbon steels (Hypertherm USA 2004) at high speeds with better accuracies, surface finish and lowest operating costs. The investment is higher compared to the oxyfuel process. Laser cutting is a photophysical process which cuts metal as well as non-metals due to concentrated strength of a fine focused high energy light beam. This process is high tech and gaining popularity at present. In India, the present trend shows major tilt towards this process due to high accuracies, speed, aesthetically superior cuts and almost no post cutting activity. All these processes can be automated to meet the industrial demand and selected on the basis of applications, productivity, reliability, skills available, operational economics and capex costs. Outcomes ensure the classification of the machine operators, machinists & deskilling. For eg: replacing a machinist with a NC [numerically controlled] or CNC [computer numerically controlled] machine. Additionally , we ensure that evaluation of individual aptitudes , creation of skill pools , overall cost reduction & overall promotion of organizational discipline are prioritised. We have to also reduce organizational pressure by dealing with " arm-twisting" tactics of skilled workmen which is a common phenomenon in most Indian workshops . Finally we aim to create an adaptive and productive organization which runs on a system and strategy .

2.3 Culture as important factor to technology adoption

Culture defines the customs, ideas , beliefs etc of a society (Tylor 1920).The decision and selection automated equipment is guided primarily by technical and economic considerations . The study of people is usually neglected . Social studies are rarely given the opportunity to participate in the design of the often complex details of the actual technology that lies behind the man-machine interface (Kidd 2007). Cross-cultural adaptations (Browaeys and Price , 2014) are also becoming necessary for employees due to export commitments or foreign collaborations related challenges eg : training in foreig countries . Involving engineers and social studies with the aim of allowing the existing skills of employees to evolve into new skills in relation and effective adaptation cannot be ignored. Jobs and skills are like food and oxygen for developing countries including a growing concern of skills mismatch (Maclean , Jagannathan , Sarvi 2013). Benefits can be derived from studying the practices followed in different countries and regions.

In order to change traditional beliefs and resistance , an interesting case study of Visiontech Engineering (Pune), India * a medium size company was studied . They translated the advantages gained into a cost to benefit analysis after invesing in a CNC fibre laser cutting machine as an alternative to the conventional processes they were using.

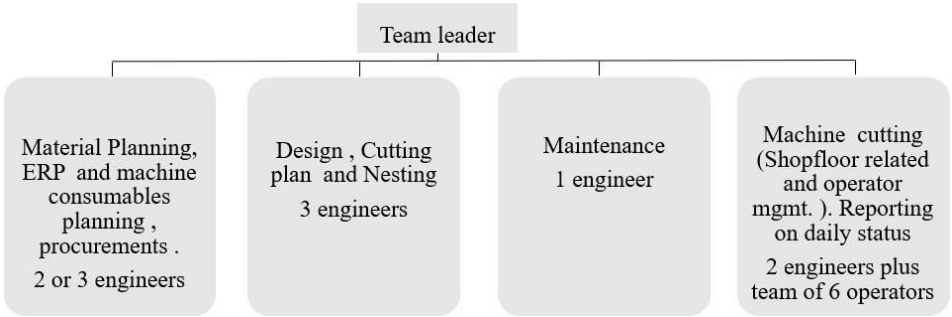
This was calculated on the basis of 2 shifts a day of 6 hrs each , 6 working days a week , 300 working days per year . Lower set up times , almost nil rejections ,minimised scrap, raw material saving and labour cost savings were the additional advantages .

Payback was within 1 year making this conclusion extremely relevant to our study.

In the Indian context , such equipment can be used non-stop for 2 or even 3 shifts a day , 6 working days a week ,only needing to be switched off for routine maintenance. Components produced are highly repeatable , accurate and consistent . Machines can be upgraded by implementing software updates .Training and prototyping can be done virtually using software . It has been noticed that the operational skills needed to work on these machines are getting simpler with software upgradations.

The key skill lies in planning , operations and logisitics. Fig 2.2 shows the " Cutting management group " depicting an organisational initiative aiming to increase production volumes , quick design adaptation , better material planning and creating necessary skill surplus .

Figure 2.2 Cutting management group



Source: Tejas Engineering and management, Mumbai

According to an interesting study (Schmitz UOT 2021) , there is a lack of motivation among

the young people to pursue a career in shopfloors. The numbers opting for vocational studies are still 10 times lower than the target . Many, also opt of careers outside manufacturing (Ryan , 2023). He adds there is a need to convince both young people and their parents that there is a lack of understanding of what manufacturing facilities look like today. They need to understand that this is a high-tech industry that enables people to work with computers and build rewarding careers . A career in industrial fabrication can rewarding, for a skilled metal processing work-force (Marker ,2017). Production, quality control, maintenance , supply chain management and design are areas that are capable of offering job satisfaction and right compensation (Ratliff , 2023).

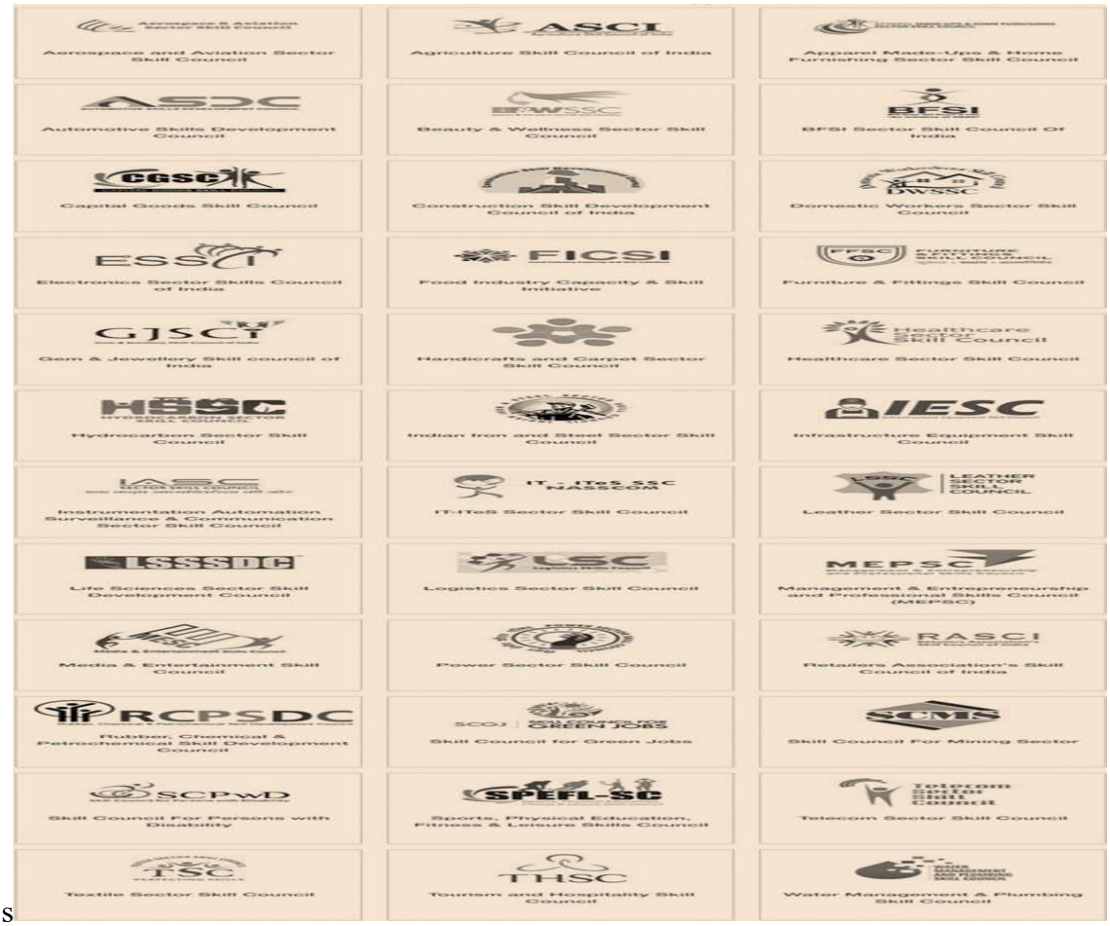
The Indian context is very different . 140 Billion plus population , 25 % population below 35 yrs age and over 50 % population below 25 yrs age makes a valid point for opportunities available and future potential to become a strong global manufacturing hub. A study by the Skill Development Council (NSDC) indicates that there will be a need for around 150 million skilled work force by 2025 across 36 key sectors,(refer figure 2.3).

Since the introduction of Fibre & Disc* lasers in India, the state-of-the-art of laser cutting systems have replaced traditional expensive CO2 lasers. Recent develoments have seen laser cutting with power as high as 40 KW (Bystronic 2022). Laser cutting is no longer restricted to precision and thin sheet cutting . It is now replacing many plasma and oxy-fuel cutting jobs opening avenues for higher accuracies , cleaner and affordable technologies. Intensive use of CAD- CAM simulation etc allows optimization of individual machines . CNC thermal cutting operations focus on reducing scrap , reduced set-up time , use geometrical data , create toolpaths and machine functions via Automatic or Manual Nesting* offline programming software packages (Software for mathemaical calculation of better yeild from raw material) . CNC Thermal cutting operation job requirements (Chen, 2024) are as under :

1. Operate the machine.
2. Responsible for troubleshooting cutting and process technology.
3. Machine uptime and regular maintenance

Post cutting operations such as welding , bending , punching, machining etc are part of the production planning and process automation .An integrated production planning model is aimed at creating feasible groupings of parts while at the same time minimizing the number of time-consuming setups in parallel as well as post cutting operations . Simulation is extensively used for evaluation to arrive at highest output , lowest rejections and optimised cycle time .

Fig 2.3 36 Key sectors



Source : NSDC , Mumbai

2.4 Servitization

The concept of Servitization (Vandermerewe and Rada 1988)is the process of creating value by adding services to products.The demand for a stronger customer relationship; better alignment with expectations and improvement of product for better product-market alignment , suffocate the competitors , create a recurring income stream which enables companies to have decent cash flows and meet operational expenses without digging into the profits or reserves .

International socio-economuc pressures and competitive business environments are forcing business entities to look beyond goods based business propositions. Competing on the basis of value addition is becoming the successful model. The advantages are manifold however , documented and powerful techniques are yet to be implemented in many industries .

The potential is unlimited . Servitization will stand strong on the foundations that include market research , resource mobilisation , skilled manpower and management support.

2.5 Use of digital tools

Companies have developed CAD systems (Petteri 2021) , which offer possibilities such as techncial reviews for the detection of errors at the earlier stage and thereby reduce costs. The

above study clearly highlighted 65% of mechanical/electrical errors and 57% of improvement potential in errors . It is possible to carry out the flexible manufacturing of any part . Computer programs and interfaces are required for this purpose. The CAD system suitable for the input of part data and which is externally accessible, along with proper interface followed by sequencing of operations is possible to be implemented in CNC thermal cutting just like its done with standard machine tools . Adaptability to any new information or upgrade is an added feature . We are rapidly moving into the environment of AI (Artificial intelligence) and IOT (Internet of things) . We operate with high speed data
Transfer with 5G technology . It is critical for these systems to be implemented on the shopfloor , and other line operations (Augmentir , 2024) .

Our study is incomplete without having a brief look at the magnitude of vocational education system in China , refer figure 2.4. Vocational training in China has been playing a vital role with over 20,000 schools compared to approximately 4000 in India At present, vocational training is mainly managed by government however , corporations are encouraged to train their own employees. The growth rate of the vocational training industry is governed by some key factors (Fu , 2023) . We list them down as under ;

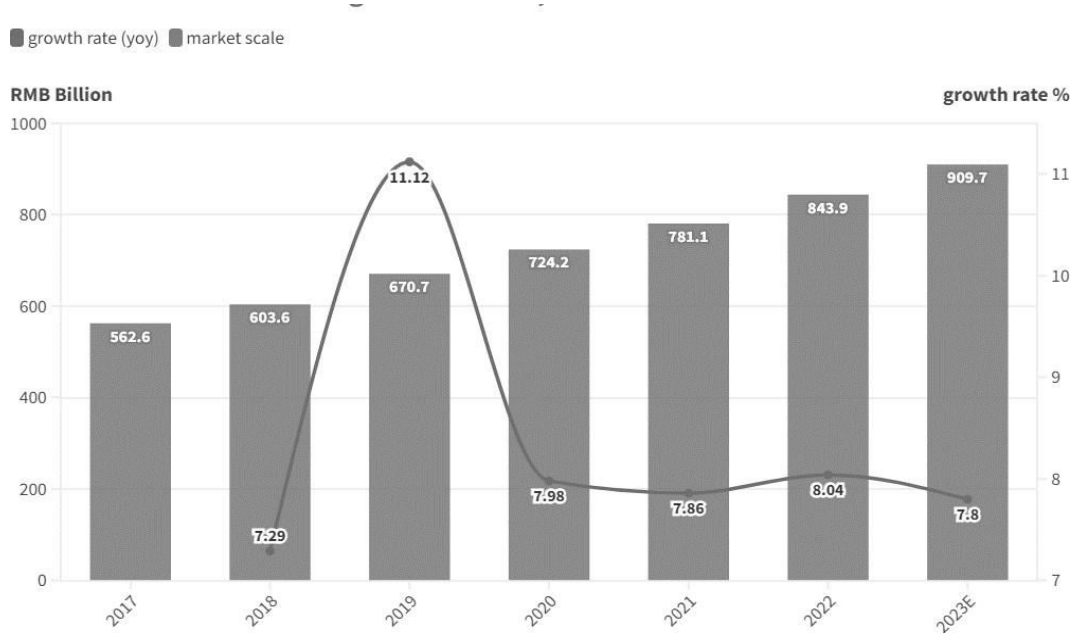
Policy : The attention to vocational training is backed by legislation.

Social: Improvement in income and better career prospects is not a secret. This encourages others to follow.

Workforce : Hight-tech manufacturing and progress requires updated skills.

Suitability : With the increase in educated population and natural disasters like the pandemic there is an unemployment challenge . Vocational training increases employment prospects.

Fig 2.4 Vocational training market size in China



Source www.aski.com

Industry 4.0 compatibility is soon becoming a standard. Performance of thermal cutting is not

isolated from these global develoments .Roadmaps are being drawn to achieve process excellence and conformity to globally acceptable standards .The future skill-set will be incomplete without the the of knowledge of technology and data science or management.
Predictive analysis (Sharma Upgrad 2022) is a process used for measuring future throughput with historical data and improvements made therein .Inventory management , risk analysis, level of automation required , capex requirements ,design and manufacturing process improvements are studied and implemented. In CNC thermal cutting , we find synergy with respect to the equipment uptime, critical consumables and spareparts planning
adopting the lowest cost of manufacturing technologies and implementation of dedicated modelling software packages designed to serve specific industries such as sheet metal , shipbuilding or structural fabrication etc which contibute towards national infrastructure development and growth . Additionally its important to know why an understanding finance provides a significant edge in the steel fabrication segment (Academyflex ,2024) . Machine operators need to learn cutting technologies and metal processing, and trouble shooting skills (Chen , 2024) ensuring the quality and efficiency .Industry is developing fast . Technologies considered unaffordable 5 to 6 years back are easily affordable today . eg : Fibre laser cutting machines are no longer restricted to sheet metal or high precision applications .They are also fast replacing traditional processess like oxy-fuel and plasma cutting.. Major advantages being high accuracy levels ,less wastage , speed ,lower operating costs , easy to install and lesser pollution (He ,Xie, Lin ,Yao ,Wang ,Liu ,Chen ,Sun 2022)

2.6 Summary of the Literature Review

We can conclude that CNC Thermal cutting is a high-tech process now and needs to be taken seriously. A strong infrastructure is necessary for any manufacturing sector to grow (Mehta & Rajan , 2017) .The available unskilled workforce, who constitute about 90% of the labour force, (MSODE , 2019) are unfit with no exposure to any form of formal training. Additionally , vocational courses are considered at a lower status level in the Indian society (Todariya, 2019) .Manufacturing Technologies are rapidly changing . Its important to be trained and regularly refreshed on the same .India provides the highest young working population and a huge scale manufacturing is predicted. After China , India is poised to be the next manufacturing hub of the world. Skill development is essential to enable machine operating abilities , machine maintenance abilities , design related improvements and selection of right technologies .Excellence can be achieved through use of data management , predictive analysis & available scientific tools. While on the subject , we also add importance to the employee " Soft skills " which can be beneficial to the mental health and overall well-being of an individual (Bundle - Linkedin , 2024) . Emotional quotient is yet another important area . Emotional Quotient (EQ) is the ability to understand, use, and manage your and others emotions effectively skillfully (Goleman , 1964 In fact, recent SHRM (Society for human resource management) studies showed that over 60 % employees are working during vacations, and a an estimated 40% feel guilty for taking time off (Rao, 2010) . Training on management education , new technology adaptation and pursueing a clean environment based manufacturing supplements the above goals .

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CHAPTER 3
METHODOLOGY

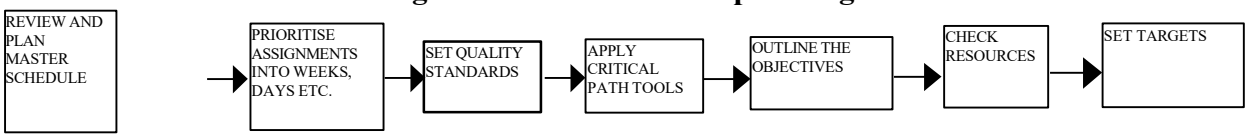
3.1 Introduction

CNC thermal cutting operation is the backbone activity when it comes to processing steel meant for building national or international infrastructure. It demands specialized skills. Skill development in this area has its own set of challenges. Lack or poor availability of the same is a major constraint and a sizeable hurdle in the infrastructural growth process. By definition, constraints refer to the available manpower, training institutions, industry focus, finance, logistics etc. (FICCI, 2010) . It's essential to examine the areas which could be preventing our goals and objectives. The infrastructure & construction industry, which consumes around 45-62% of total steel produced (Irfan , Varadarajan, Mateen , Mobashir, Kumar & Shukla , 2023). Successful execution and control of an infrastructural project relies on effective identification and management of constraints through master planning and especially, short-term look-ahead scheduling (Let's build, 2022). That being said, we will examine the tools that will be required to implement to manage lookahead planning and the master schedule. We have included CNC thermal cutting process as part of the look ahead scheduling process. Six important aspects will have to be considered as under (Choo, Tommelein, Ballard, & Zabele, 1998) :

1. They should enable smooth connectivity and corelation to all project updates to the overall Plan in real time.
2. They should be linked to one source of truth keeping everyone on the same page and Facilitating the automation of the reporting process.
3. They should offer an always up-to-date audit trail that will allow project stakeholders to relate to historical data. This will also protect ring-fence from any legal issues that could become a serious matter in future.
4. A common platform to link all applications and progress Ease of use and easy "in-situ" adaptation.

It's advantageous to be domain specific & to choose tools that have been built after taking into consideration the true needs of the people who actually work in the infrastructure segment .The steps involved (Choo, Tommelein, Ballard & Zabele, 1998) are outlined in figure 3.1.

Figure 3.1 : Look ahead planning



Source: https://leanconstruction.org.uk/wp-

While the master schedule provides a macro view of a project and the overall execution strategy, a look-ahead schedule offers a detail account of operational constraints and a detailed plan showing work to be done within a relatively short time window. Ideally, these detailed schedules should reflect actual field conditions and provide field personnel with operation instructions free of constraints and conflicts using mathematical models such as

partial differential equations (Hinze, Pinnau & Ulbrich, 2008). This research project will provide an overview of the examination of the skills for facilitating CNC thermal cutting operations to meet the infrastructure demand in India. Managing the constraints will further lead to success towards achieving overall national progress and development.

3.2 " Make in India " Initiative

The present Prime Minister of India Sh Narendra Modi has emphasized the need for strong manufacturing sector in India with a grand vision aimed at creating over a 100 million jobs immediately . The idea is to become a manufacturing hub for Global requirements and provide a workable option against Chinese manufacturers who at present are most preferred. India is one of the fastest growing major economies and has a rising young workforce. Running high on this momentum, the government has initiated several policies such as 'Skill India' and 'Digital India' to complement 'Make in India' (Chenoy , Ghosh & Shukla , 2019). Manufacturers are stressing on developing the right skills to address the growing skill gap in various manufacturing sectors in the context of changing industrial landscape defined adaptation to new-age technologies.

A strong infrastructure is necessary for any manufacturing sector to grow. (Mehta & Rajan, 2017) Keeping that in mind the government of India is investing sizeable level of funds towards building a strong network of roads, rails and transport to foster the growth of the manufacturing sector .The requirements of skill towards processing steel are also getting complex . The current data suggest that approximately 2 to 3 % of the workforce in India have undergone formal skill training as compared to 70 % in the UK, 75 to 80 % in Germany, 50% in USA, 80 to 90 % in Japan and almost 95 % in South Korea (Sharma & Nagendra , 2016) . It is an alarming signal for India which has the youngest population in the world. Data from the World Bank indicated that in 2013, the contribution of manufacturing sector to Indian Economy was lesser than 15 % (Goyal, Kaur, & Singh, 2015). The overall contribution to GDP by manufacturing sector was lower than 30 % . India"s contribution to world's manufacturing was insignificant at lower than 2 % . (Goyal, Kaur, & Singh, 2015) . Laser cutting is commonly being adopted by the manufacturing industry (Naresh & Khatak, 2022). The applications widely caters to the automotive, aerospace, shipbuilding, infrastructure and various other manufacturing industries The laser cutting process can be utilized for cutting a wide range of materials , metal as well as non metal .Challenges in thermal cutting are overcome with education. eg : offshore steel structures covered with nonconductive substances such as rust, mud, and were overcome by creating lateral water flow with double layer workpiece (Liu, Sun , Wu & Ma , 2023) .

3.3 Problem Statement

India's GDP is expected to rise from $2.5 trillion in 2019 to $5 trillion in 2025 and 9 trillion in 2030, according to a Bloomberg (Roy , 2023). A national survey (India skills report , 2015) recorded that that India lags behind in the development of skills. Of all the students applying for roles in the labour market, a mere 1/3rd of the number had the appropriate skills to match the requirement of the employers. (Rai ,2016).Though we have sufficient manpower but they are not skilled enough to get According to 12th Plan Document of the Planning Commission, approximately 80 to 85 % percent of the labour force in India have educational

qualification up to secondary level within which 50to 55 % per cent have an educational qualification only up to the primary level and merely 2 to 3 % of the workforce have any vocational training(Rai ,2016).Government initiatives have not met the desired goals in terms of creating opportunities for skill development training in India (Linkedin survey 2018).

These goals include:

1. Increasing professional efficiency
2. Expanding skill domain
3. Time management
4. Higher output.

The importance of developing a constraint-free and reliable work plan has long been recognized by the industry. However, numerous projects are still plagued by delays and cost overruns, which can frequently be traced to ineffective identification and treatment of constraints. First, when a constraint is not properly identified during scheduling, subsequent conflicts in the field are inevitable. Today's projects are becoming more and more technically complex and logistically challenging, which exposes all project operations to even more complex constraints. Second, the traditional scheduling methods, bar charts and Critical Path Method (CPM) which are widely used as a basis for constraint analysis also rely on assumptions (Wallace, 2010). Our area of research will examine skill development and constraints in CNC thermal cutting operations with respect to the infrastructure industry demand . Steel cannot be processed without CNC Thermal cutting.

Our constraints are structural and functional in nature (Garg, 2022). By structural we refer to underdeveloped manufacturing sectors, informal sectors with low skilled work forces, poverty, lack of clear job description and political interferences. Functional constraints refer to limited training facilities which are estimated to be lower than 20 % of national demand, Lack of incentives facilitating a learning culture and large pools of casual labor, typically rural migrants with no education or support of any kind.

We plan to address an important area which contributes significantly towards the identified limitations or constraints namely, non-availability of skilled manpower. In summary, there is a need for a better understanding of constraints in the industry and a structured approach towards ensuring a constraint-free work plan (Bhattacharya 2020). More specifically, the following research questions need to be addressed:

1. What are the typical constraints found in CNC Thermal cutting operations?
2. How to classify these constraints for easier identification and modeling?
3. What are the current industry practice adopted to resolve the constraints?
4. How to connect the constraint classification knowledge into a framework for total constraint management?

3.4 Research objectives

The long-term goal of the research is to develop a formalized constraint management system. Constraint management is defined herein as the process of identifying, classifying, modeling, and resolving constraints (Garg, 2022). The objective of the current study is to provide a comprehensive review of literatures and industry practices in relation to CNC Thermal cutting

skills scenario and outline a conceptual framework for constraint management via survey , interviews and published data to provide a comprehensive review of sources and characteristics of challenges typically found in construction , infrastructure projects and further develop a base for constraint classification, methods etc for easier identification and providing necessary inputs for modelling in future. We also review current industry practices and research to suggest a structured input for total constraint management addressing the direct as well as indirect relevant skills , consequentially leading to reduced construction times , lower costs of processing , flexibility towards expansion , quality assurance , lower maintainence costs , energy efficiency , aesthetical edge , efficient logistics and accountability.
The result of this study will be valuable to the industry practitioners as well as relevant software providers towards developing better practices and tools for constraint management and look-ahead scheduling. Thermal cutting requires a sequential approach for effective utilization and profitability (Sherif ,Jawahar & Balamurli ,2014). Nesting and cutting sequences determine the same . Creating a cutting plan with optimum time and raw material utilization are key factors to be addressed in the shopfloors. The primary objective of a skilled operator is to deliver the focused beam to the metallic plates or sheets referred to as work pieces (Powell, 1993) . This has to be coupled with management of raw material and lowest cost of operation with maximum yield. Manufacturing relies a lot on “data mining ” to understand the impact of thermal cutting process vs mathematical simulations (Tercan , Khawli , Eppelt , Buscher , Meisen & Jeschke ,2017). Manufacturing teams need to adopt a hybrid approach covering machine specifications versus process limitations and historical data.

3.5 Preliminary Literature Review Objectives

Charles Darwin said, "It is not the strongest of the species that survives, nor the most intelligent; it is the one most adaptable to change.". Our work environment can be described as Volatile, Uncertain ,Complex & Ambiguous (Patel ,2022) .The large demography of India is best utilized only when the employees are trained on present and the envisioned future skill set requirements (Behera & Gaur , 2022) .In today’s context , it has been observed that the main reason behind the arising skill and employability is digitization and technological advancement (Raju , 2023). The approaches suggested in various studies conducted for reducing the skill gaps can be Educational institutions – industry collaborative approach, vocational trade education, project management training , internships / apprenticeships , train the trainer initiaives (Raju , 2023) . There has been several initiatives taken by Indian government on skill development. Studies also indicate the importance of “soft skills” to enhance employability. In adequate preparation has to be tackled with interdisciplinary approach starting from primary schools. (Thomas & Unninarayanan , 2018) .Figure 3.1 indicates the present structure showing roles and responsibilities of the various entities involved in the Skill development initiatives (KPMG , 2023).

Table 3.1 Present structure showing roles and responsibilities of the various entities involved in the Skill development initiatives

Government	Facilitators	Educational Institutions	Target
• Ministry of Skill development and enterpreunersh ip • MHRD • MoRD • Others	• State skill development mission • NSDC • NSDA • SSCs • NCVT • Labour laws • Minimum wages act • Financial institutions • Apprenticesh ip act	• AVTSs • Private training schools • Training by employers • Schools • Colleges • Asseseme nt centres	• Marginalise d societies • Unemploye d • Low salaried sections • Students

Source : KPMG

A preliminary literature review covering the Indian perspective show that past studies are primarily focused mainly on the initiatives taken by the government of India and the limited private industry participation (Palit, 2009).

Present day key initiatives (Dristiias ,2019) include ;

Skill India programme

Pradhan Mantri Kaushal Vikas Yojana (PMKVY),

Creation of Ministry of Skill Development

CNC thermal cutting as a process has not been addressed in detail despite its importance and contribution towards productivity and profits. Limited progress has been made on classifying various ground level constraints in a comprehensive manner. We look at key unexplored areas such as:

Ethnicity distribution of skilled work force in various zones. Aspirations of prospective candidates and how it affects our research co-relating the above with different age groups and job-oriented formal education.

Role of women in all spheres of the industrial work force Creating attractiveness in shopfloor related jobs demanding specialized skills.

International study does covers few of the above areas, especially addressal of motivation among prospective candidates, implementation of concepts such as “Servitization” (Vandermerwe & Rada, 1988) , Technological advances and Digitalization, Data science in manufacturing (Rohit Sharma, 2022) addresses the potential of information and its role towards infrastructural development. The above study clearly establishes the link between data management and skilling initiatives. Servitization however is not a complete cure for manufactures (Baines, Lightfoot, Benedettini, Kay,2009). It is a concept with high potential value, providing road-map for companies to move up the value chain and exploit higher value business activities and organizational skills .

The newly-established National Skill Development Corporation (NSDC), comprising distinguished technical professionals is in process of setting up industry-specific skill councils (Palit, 2009). It will play a pivotal role in forging skills development initiatives by involving the private sector through public-private-partnerships (PPPs). Efforts have already been initiated to establish additional 1500 Industrial training institutes and over 4500 skills development centers through the PPP mode. The new policy is also expected to set standards for competency-based qualifications and certificates on national- approved criteria. The NSDC, ITIs and polytechnics are expected to substantially increase their training capacities over the next decade so as to achieve the target of equipping/training over 500 million people within the next 3 years. Our research aims to identify the constraints and connects it to the examination of the skills for facilitating CNC thermal cutting operations to meet the infrastructure demand in India.

3.6 Methodology: The subject chosen for study is unique and has not received the appropriate attention worldwide .Our primary research method for this study is through a pin-pointed brief survey comprising key questions (refer appendix A) which will help identify the zonal constraints / challenges in India connecting it to our research subject. These questions will be answered through online surveys and personal interviews with industry heads, managers, vocational schools etc. Constraint identification and classification through a structured approach is the very first step towards a "zero-constraint" environment (Garg, 2022). Understanding social, locational and age related factors will enable deeper study and examination of skills in the area of CNC Thermal cutting and their role in the challenges in infrastructure development . This study reviews various types of constraints being faced by industry in getting skilled work force and their characteristics going deeper into areas that will enhance the defined skills , help in modelling a successful career and also point out towards other peripheral skills that will enhance performance and progress . Based on this understanding, a classification method will be developed to categorize constraint factors for the purpose of constraint identification through discussion points against each question . In the second stage of this study, existing challenges will be identified based on a comprehensive review of current industry practices and academic researches. Finally, once the constraint classifications are identified, a suggestive framework for total constraint management will be outlined under conclusion section citing practical examples . This study will be conducted between January 2024 to December 2024.

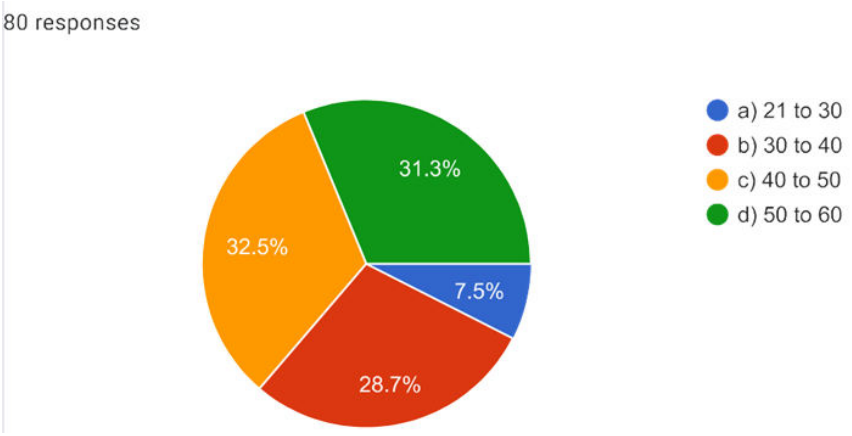
***

CHAPTER 4
RESULTS

4.1 Introduction

This chapter presents a detailed account of the findings from the research, derived from the methodologies outlined in the previous chapters. This section aims to provide a clear and objective representation of the data collected, highlighting key patterns, trends, and insights that emerged from the analysis. By systematically presenting the results, this serves as a foundation for interpreting the implications and relevance of the research, setting the stage for a comprehensive discussion in the subsequent sections.

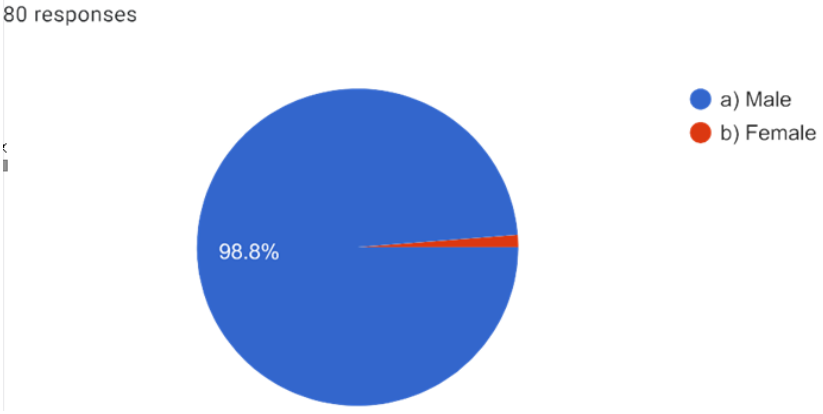
Figure 4.1 What is your age group?



Source: Author

The Graph shows age distribution of 80 respondents. The largest segment, representing 32.5% of the respondents, falls within the 40 to 50 age group. The second-largest group, comprising 31.3%, is aged between 50 to 60 years. Following this, 28.7% of respondents are in the 30 to 40-age bracket. The smallest group, making up 7.5%, consists of individuals aged 21 to 30. This distribution suggests a higher representation of middle-aged and older adults among the respondents, with fewer young adults participating in the survey.

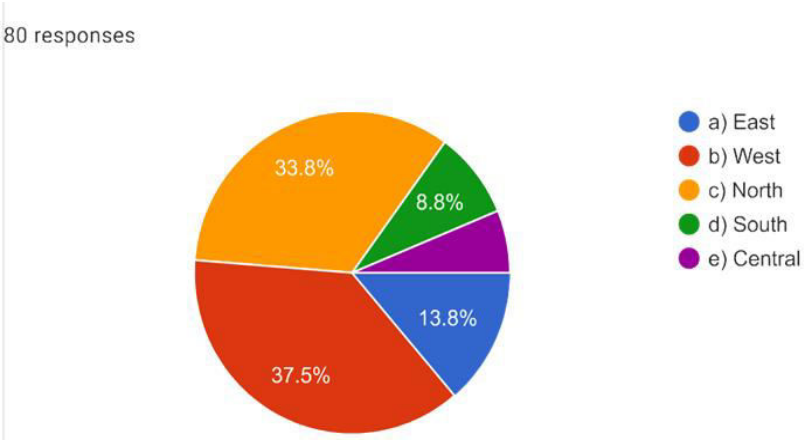
Figure 4.2 What is your Gender



Source: Author

The Graph shows the gender distribution of 80 respondents. An overwhelming majority of the respondents, 98.8%, are male. In contrast, a very small fraction, represented by the thin red slice, indicates that only 1.2% of the respondents are female. This significant disparity suggests that the sample population is predominantly male, with female representation being almost negligible. This could imply a gender imbalance in the context in which this survey was conducted, indicating a potential area for further investigation or targeted outreach to ensure more balanced gender representation in future surveys.

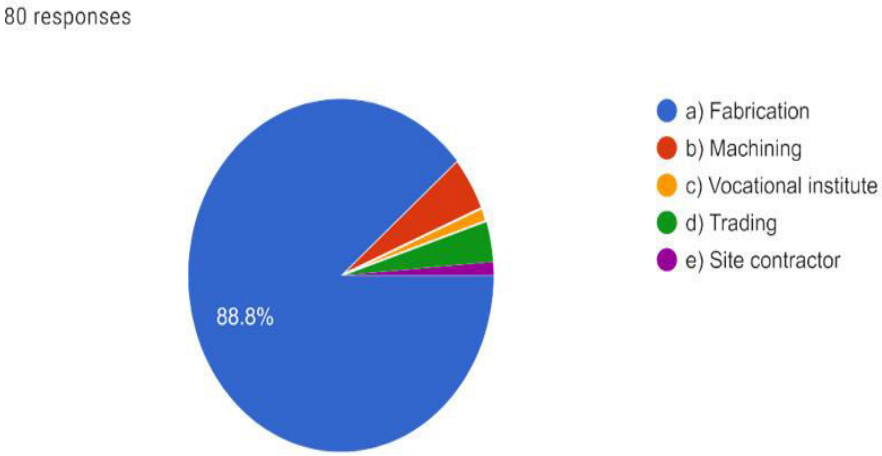
Figure 4.3 Please specify the location of your workplace in india



Source: Author

The Graph shows the geographical distribution of the workplaces of 80 respondents across India. The largest segment, representing 37.5%, indicates that the majority of respondents work in the western region of India. Following this, 33.8% of respondents are based in the northern region. The southern region accounts for 13.8% of the respondents' workplaces. The eastern region has a smaller representation at 8.8%, while the central region is the least represented, comprising only 6.3% of the respondents. This distribution suggests a higher concentration of workplaces in the western and northern parts of India, with relatively fewer workplaces in the eastern and central regions.

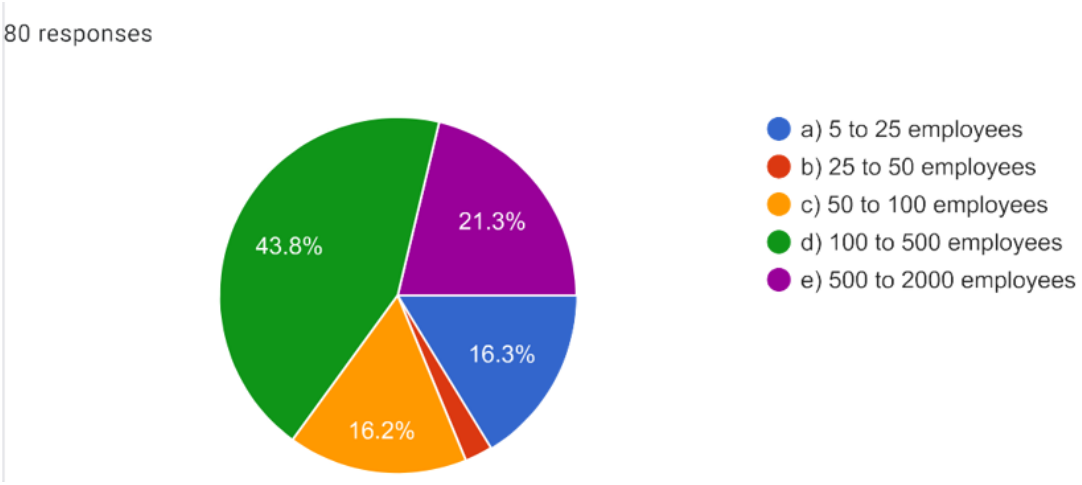
Figure 4.4 What is your industry / institution type?



Source: Author

The pie chart displays the distribution of industry or institution types among 80 respondents. The majority, 88.8%, are involved in fabrication, as represented by the large blue segment. The other industry types include machining, vocational institutes, trading, and site contractors, but they each comprise a much smaller portion of the total. Specifically, machining, vocational institutes, trading, and site contractors make up the remaining 11.2%, indicating that these industries are significantly less represented compared to fabrication. This suggests that the sample is predominantly from the fabrication sector, with minimal participation from other industries.

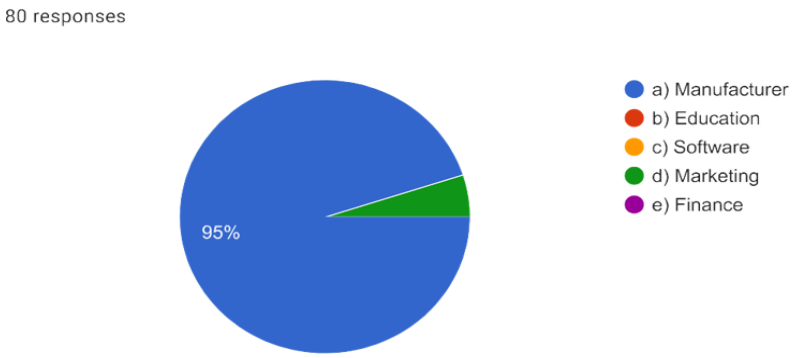
Figure 4.5 What is the size of your organization



Source: Author

The Graph shows the size distribution of organizations based on the number of employees among 80 respondents. The largest segment, comprising 43.8% of respondents, represents organizations with 100 to 500 employees. This is followed by organizations with 500 to 2000 employees, making up 21.3% of the respondents. Smaller organizations are less represented, with 16.3% having 5 to 25 employees, 16.2% having 50 to 100 employees, and the smallest group, 2.5%, consisting of organizations with 25 to 50 employees. This indicates a varied distribution of organization sizes, with a notable concentration in medium to large-sized organizations (100 to 500 employees).

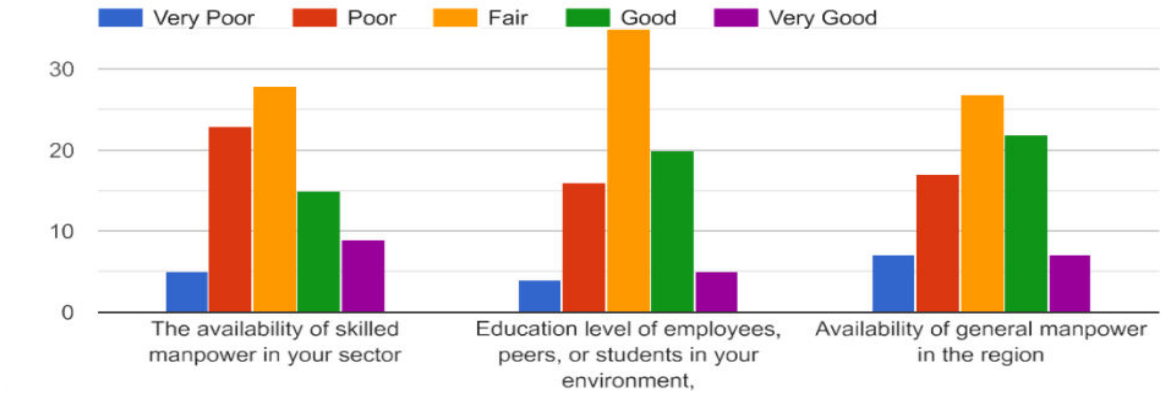
Figure 4.6 What type of activity best describes your role or work?



Source: Author

The Graph shows the distribution of respondents' roles or work activities among 80 responses. A dominant 95% of respondents identify their role as related to manufacturing, indicated by the large blue segment. The remaining 5% are involved in marketing, represented by the green segment. Notably, none of the respondents selected education, software, or finance as their primary activity. This highlights a significant concentration of roles in manufacturing, with minimal representation in other professional activities such as marketing and an absence in education, software, and finance sectors among the respondents.

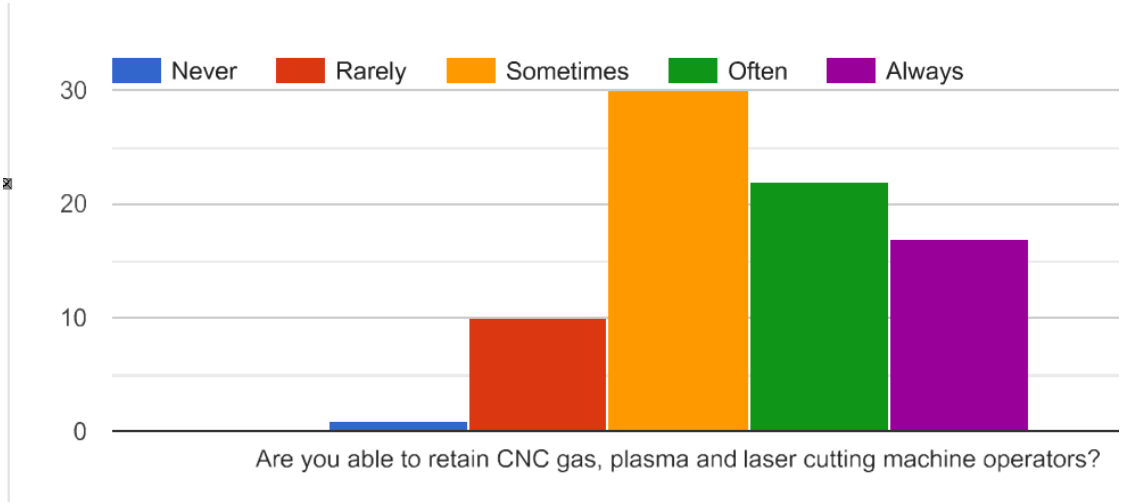
Figure 4.7 Skill education and manpower availability related to cnc Thermal cutting (CNC Gas , Plasma & laser cutting)



Source: Author

The bar graph provides an overview of the perceptions regarding skills, education, and manpower availability related to CNC thermal cutting (including CNC gas, plasma, and laser cutting). It covers three key areas: the availability of skilled manpower in the sector, the education level of employees or students, and the availability of general manpower in the region. For the availability of skilled manpower in the sector, the majority rated it as 'Poor,' followed by 'Fair,' and smaller portions rated it 'Very Poor,' 'Good,' and 'Very Good.' Regarding the education level of employees, peers, or students, 'Good' received the highest rating, with 'Poor' and 'Fair' also being significant. 'Very Good' and 'Very Poor' had lower ratings. For the availability of general manpower in the region, 'Poor' and 'Fair' were the most common responses, with 'Good' also notable. 'Very Poor' and 'Very Good' were the least common ratings. Overall, the data suggests that while education levels are viewed positively, there are concerns about the availability of skilled and general manpower in the CNC thermal cutting sector.

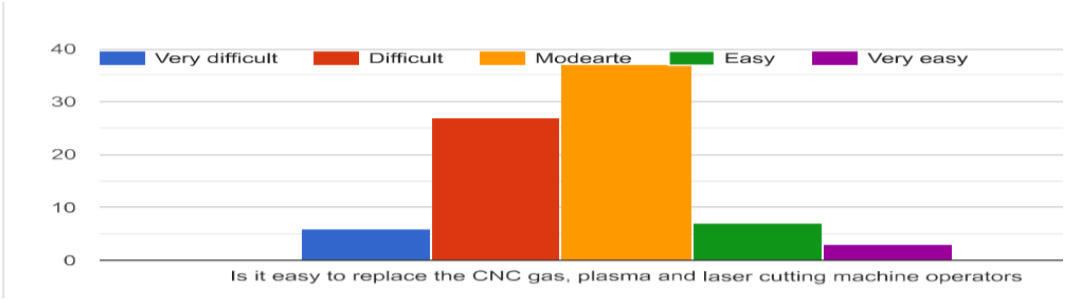
Figure 4.8 Employee retention related to CNC Thermal Cutting



Source: Author

The graph illustrates employee retention related to CNC (Computer Numerical Control) thermal cutting, specifically for CNC gas, plasma, and laser cutting machine operators. The data is categorized into five retention frequency categories: Never, Rarely, Sometimes, Often, and Always. The most significant category is "Sometimes," with approximately 30 respondents indicating this frequency, suggesting that retaining these operators is an occasional occurrence rather than a consistent trend. The next most frequent category is "Often," with around 20 respondents, indicating a notable portion of employers are able to retain operators frequently. The "Always" category, with about 10 respondents, shows that a smaller group of employers consistently retains their operators. Conversely, the "Rarely" category has approximately 5 respondents, indicating that a few employers struggle with retention. The "Never" category has the least respondents, close to 1, suggesting that it is quite rare for employers to never retain their CNC thermal cutting operators.

Figure 4.9 Employee availability related to CNC Thermal Cutting

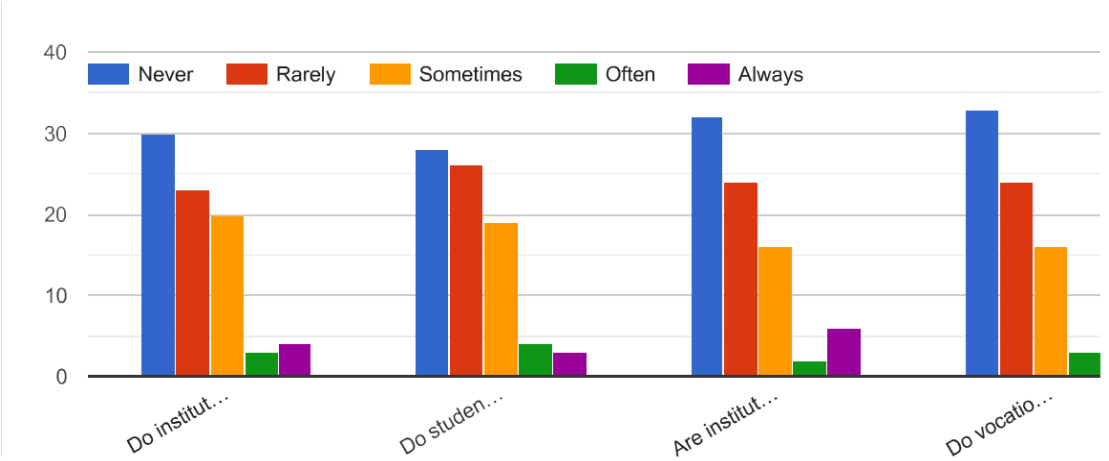


Source: Author

The graph depicts the availability of employees related to CNC thermal cutting, specifically addressing how easy it is to replace CNC gas, plasma, and laser cutting machine operators. The responses are divided into five categories: Very Difficult, Difficult, Moderate, Easy, and Very Easy. The largest category is "Moderate," with around 35 respondents indicating this level of ease in replacing operators. This suggests that for many employers, finding replacements is neither particularly challenging nor effortless but falls somewhere in

between. The "Difficult" category follows, with approximately 25 respondents, indicating that a significant portion of employers find it challenging to replace these operators. The "Easy" category has around 10 respondents, showing that a smaller group of employers finds it relatively easy to replace operators. "Very difficult" has about 5 respondents, indicating a minor but notable group experiencing substantial difficulty in finding replacements. Finally, the "Very Easy" category has the fewest respondents, close to 2, suggesting that it is quite rare for employers to find replacing operators very easy.

Figure 4.10 Educational Institutions & their roles to CNC thermal cutting

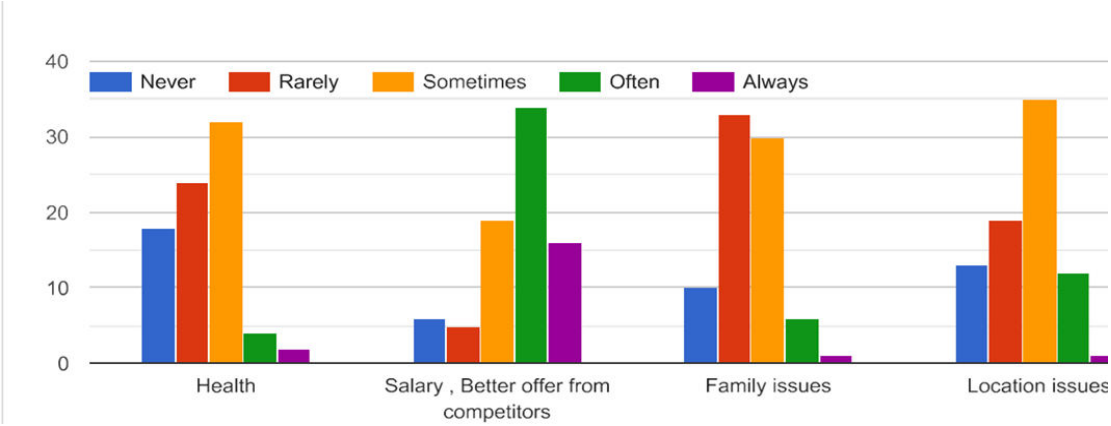


Source: Author

The graph examines the roles of educational institutions in CNC thermal cutting, divided into three questions regarding institutions, students, and vocational schools' contributions to the field. For the first question, "Do institutions offer CNC thermal cutting programs?" the "Never" category has the highest response, with about 30 respondents indicating that institutions do not offer such programs. "Rarely" follows with approximately 15 respondents, and "Sometimes" with around 20 respondents, suggesting some presence of these programs, but not consistently. The "Often" and "Always" categories have fewer responses, around 5 and 1, respectively, indicating that only a small number of institutions frequently or always offer these programs. Similarly, for the second question, "Do students get practical exposure to CNC thermal cutting?" the "Never" category again has the highest response, with around 30 respondents, indicating that students often do not receive practical exposure. "Rarely" follows with approximately 15 respondents and "Sometimes" with about 20 respondents, suggesting occasional practical exposure. The "Often" and "Always" categories have fewer responses, around 5 and 1, respectively, indicating infrequent or consistent practical exposure. For the third question, "Do vocational schools provide specialized training in CNC thermal cutting?" the "Never" category continues to dominate, with around 30 respondents, suggesting that vocational schools frequently do not provide specialized training. "Rarely" follows with approximately 15 respondents and "Sometimes" with about 20 respondents, indicating some presence of specialized training. The "Often" and "Always" categories have fewer responses, around 5 and 1, respectively, indicating limited frequent or consistent specialized training. In summary, the graph highlights that educational institutions, including

vocational schools, largely do not offer programs, practical exposure, or specialized training in CNC thermal cutting, with the majority of respondents indicating "Never" or "Rarely" across all three questions.

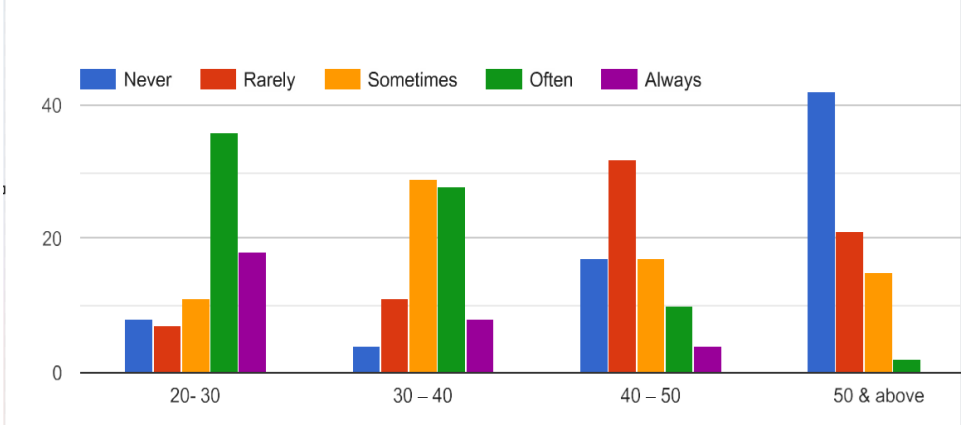
Figure 4.11 Reasons for employee attrition (leaving job) related to CNC Thermal Cutting



Source: Author

The graph shows various reasons for employee attrition in the CNC Thermal cutting sector, categorized by frequency: Never, Rarely, Sometimes, Often, and Always. Health issues are most frequently cited as "Sometimes" leading to attrition, with significant mentions also in "Rarely" and "Never" categories. Salary and better offers from competitors are predominantly "Often" a reason for leaving, followed by "Always." Family issues are most frequently "Rarely" cited, with notable responses in "Sometimes" and "Often." Location issues have a balanced distribution, with "Sometimes" being the most common response, and "Rarely" and "Often" also significant factors. Overall, salary offers from competitors and family issues are prominent reasons for leaving, while health and location issues show-varied impacts.

Figure 4.12 Age Group of candidate opting as shop floor workmen for CNC Thermal cutting

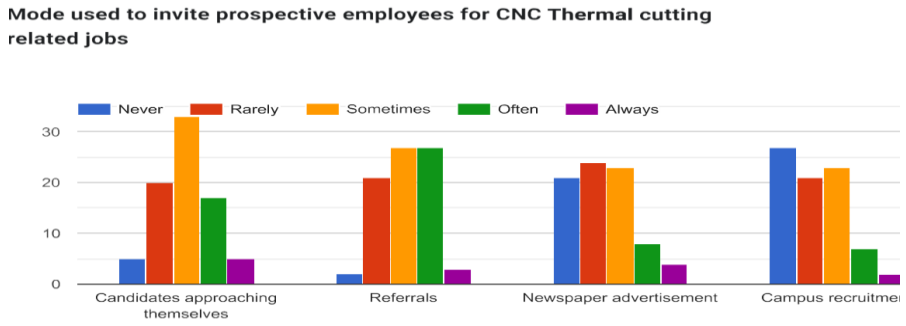


Source: Author

The graph presents the frequency of different age groups opting to work as shop floor workmen in CNC thermal cutting. The 20-30 age group is highly represented, with "Often" being the most frequent response, followed by "Always." For the 30-40 age group,

"Sometimes" is the most common response, with a significant number also indicating "Often" and "Rarely." The 40-50 age group shows a balanced distribution, with "Rarely" being the most frequent, followed closely by "Sometimes." In the 50 & above category, "Never" is the predominant response, indicating a low interest in this age group for such roles, though there are still notable responses for "Rarely" and "Sometimes." Overall, younger candidates (20-30) are more inclined towards these roles, while interest significantly decreases in the older age groups.

Figure 4.13 Mode used to invite prospective employees for CNC Thermal cutting related jobs



Source: Author

The graph shows the effectiveness of different recruitment modes for CNC Thermal cutting jobs, categorized by frequency: Never, Rarely, Sometimes, Often, and Always. Candidates approaching themselves are primarily "Sometimes" successful, with notable instances of "Often" and "Rarely." Referrals are most frequently "Sometimes" used, with significant responses for "Rarely" and "Often." Newspaper advertisements also see a balanced distribution, with "Sometimes" and "Rarely" being the most common, while "Never" has a considerable representation. Campus recruitment is predominantly "Never" effective, though it still has notable instances of "Rarely" and "Sometimes." Overall, referrals and newspaper advertisements are the most consistent recruitment modes, while candidates approaching themselves and campus recruitment show varied effectiveness.

Table 4.1 Case Processing Summary

		N	%
Cases	Valid	80	100.0
	Excluded[a]	0	.0
	Total	80	100.0

a. Listwise deletion based on all variables in the procedure.

Source: Author

Case Processing Summary" presents an overview of the data used in the analysis. It indicates that there are 80 valid cases, accounting for 100% of the dataset. There are no excluded cases, meaning no data points were omitted during the analysis process. The total number of cases remains at 80, ensuring a complete dataset for the procedure. This summary suggests that the data is intact and fully utilized in the analysis without any loss or exclusion.

Table 4.2 Reliability Statistics

Cronbach's Alpha	N of Items
.925	13

Source: Author

The given table presents the reliability statistics for a set of 13 items, with Cronbach's Alpha being the primary metric. Cronbach's Alpha is a measure of internal consistency, which indicates how closely, related a set of items are as a group. In this case, the Cronbach's Alpha value is 0.925, which is considered excellent. This high value suggests that the items have a strong internal consistency, meaning they are highly correlated with one another and likely measure the same underlying construct reliably. Therefore, the questionnaire or scale used in the study can be deemed reliable for measuring the intended variable.

Table 4.3 ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
On the scale 1 to 5, please rate the following with	Between Groups	94.855	4	23.714	213.434	.000
	Within Groups	8.333	75	.111		
	Total	103.188	79			
On the scale 1 to 5, please rate the following with	Between Groups	92.675	4	23.169	356.442	.000
	Within Groups	4.875	75	.065		
	Total	97.550	79			
On the scale 1 to 5, please rate the following with	Between Groups	18.979	4	4.745	4.338	.003
	Within Groups	82.021	75	1.094		
	Total	101.000	79			
On the scale 1 to 5, please rate the following with	Between Groups	34.831	4	8.708	4.897	.001
	Within Groups	133.357	75	1.778		
	Total	168.188	79			

Source: Author

The ANOVA table provides a statistical analysis of the differences in ratings across five groups on four different questions, each rated on a scale of 1 to 5. For the first question, the F-value is 213.434 with a significance level (Sig.) of .000, indicating a highly significant difference between groups. Similarly, the second question shows an even higher F-value of 356.442 with a significance of .000, also suggesting a highly significant difference between groups. The third question has an F-value of 4.338 and a significance of .003, indicating a significant difference, although less pronounced compared to the first two questions. The fourth question has an F-value of 4.897 with a significance of .001, showing a significant difference between the groups. Overall, the results suggest that there are statistically significant differences in the ratings across the groups for all four questions.

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Table 4.4 ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
On the scale 1 to 5, please rate the following with	Between Groups	83.704	4	20.926	152.611	.000
	Within Groups	10.284	75	.137		
	Total	93.988	79			
On the scale 1 to 5, please rate the following with	Between Groups	107.328	4	26.832	343.411	.000
	Within Groups	5.860	75	.078		
	Total	113.188	79			
On the scale 1 to 5, please rate the following with	Between Groups	98.824	4	24.706	505.816	.000
	Within Groups	3.663	75	.049		
	Total	102.488	79			
On the scale 1 to 5, please rate the following with	Between Groups	82.474	4	20.619	214.384	.000
	Within Groups	7.213	75	.096		
	Total	89.688	79			

Source: Author

The ANOVA table provided indicates the results of four separate one-way analyses of variance (ANOVA) for different rating scales, each on a 1 to 5 scale. In each case, the "Between Groups" sum of squares, degrees of freedom (df), and mean square values show the variation between the groups, while the "Within Groups" values reflect the variation within each group. The F-values are significantly high (152.611, 343.411, 505.816, and 214.384, respectively) with corresponding p-values (Sig.) of .000 for each, indicating strong statistical significance. This suggests that there are significant differences in the means of the groups for each of the rating scales analyzed. Thus, the ratings provided for each question show a statistically significant variation among the groups compared.

Table 4.5 Correlations

		On the scale 1 to 5, please rate the following with	On the scale 1 to 5, please rate the following with
On the scale 1 to 5, please rate the following with	Pearson Correlation	1	.961**
	Sig. (2-tailed)		.000
	N	80	80
On the scale 1 to 5, please rate the following with	Pearson Correlation	.961**	1
	Sig. (2-tailed)	.000	
	N	80	80

. Correlation is significant at the 0.01 level (2-tailed).

Source: Author

The provided table shows a strong positive correlation between two variables, both rated on a scale of 1 to 5. The Pearson Correlation coefficient is .961**, indicating a very high correlation between the two variables, close to 1, which implies that as one variable increases, the other variable also tends to increase in a similar manner. The significance level (Sig. 2-tailed) is .000, which is below the 0.01 threshold, indicating that the correlation is statistically significant. This means there is a less than 1% probability that the observed correlation is due to chance, thus confirming a strong and significant relationship between the two variables in the sample of 80 respondents.

4.2 Summary of Findings

The findings indicate that the largest age segment among respondents is 40 to 50 years (32.5%), followed by those aged 50 to 60 (31.3%), 30 to 40 (28.7%), and the smallest group being 21 to 30 years (7.5%). There is a significant gender imbalance, with 98.8% of respondents being male and only 1.2% female. Geographically, 37.5% of respondents work in the western region of India, 33.8% in the northern region, 13.8% in the southern region, 8.8% in the eastern region, and 6.3% in the central region. The majority (88.8%) are involved in fabrication, while the rest are in machining, vocational institutes, trading, and site contracting. Most respondents (95%) are engaged in manufacturing roles, with 5% in marketing, and none in education, software, or finance. Regarding skills and manpower availability in CNC thermal cutting, skilled manpower availability is rated mostly as 'Poor' and 'Fair,' while education levels are rated highest as 'Good,' and general manpower availability is also predominantly 'Poor' and 'Fair.' Employee retention shows that the most frequent category is "Sometimes," followed by "Often" and "Always," with "Rarely" and "Never" being less common. The ease of replacing employees is mostly "Moderate," with significant challenges indicated by "Difficult," and fewer employers finding it "Easy" or "Very Easy." Institutions rarely offer CNC thermal cutting programs, practical exposure, or specialized training, with "Never" being the predominant response. Employee attrition reasons are "Sometimes" due to health issues, "Often" and "Always" due to salary and better offers, with family and location issues showing varied impacts. Younger candidates (20-30) are more inclined to shop floor work, while interest decreases with age. Recruitment modes show that candidates approaching themselves and referrals are "Sometimes" successful, newspaper advertisements have a balanced effectiveness, and campus recruitment is predominantly ineffective.

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CHAPTER 5
DISCUSSION

5.1 Discussion of Results

The survey results provide a comprehensive overview of the demographic, geographic, and professional characteristics of the respondents, examining key trends and potential areas with respect to skills in the CNC thermal cutting sector . Results indicate the significant participation experienced individuals in the field and lower participation among youunger age groups suggesting a need to attact more young talent into the sector.

Gender distribution shows a stark imbalance with just over 1 % participation from women . This disparity highlights a significant gender gap in the CNC thermal cutting segment, emphasizing the need for targeted outreach and initiatives to encourage greater women participation. Geographically, the workplaces of respondents are primarily concentrated in the western (37.5%) and northern (33.8%) regions of India, with the southern, eastern, and central regions being less represented. This suggests that the CNC thermal cutting industry is more developed or has more opportunities in the western and northern parts of the country. In terms of industry representation, a significant majority of respondents (88.8%) are involved in fabrication, with minimal participation from machining, vocational institutes, trading, and site contractors. This indicates a strong focus on fabrication within the sample, which may reflect the broader industry trends. The size distribution of organizations shows a varied landscape, with the largest segment (43.8%) comprising organizations with 100 to 500 employees. This is followed by organizations with 500 to 2000 employees (21.3%), and smaller organizations with 5 to 25 employees (16.3%), 50 to 100 employees (16.2%), and 25 to 50 employees (2.5%). This suggests a notable concentration in medium to large-sized organizations, with smaller organizations being less represented.

Regarding the roles or work activities of respondents, a dominant 95% are involved in manufacturing, while only 5% are engaged in marketing. Notably, there is an absence of respondents in education, software, or finance, underscoring the strong focus on manufacturing within the sample. The perceptions regarding skills, education, and manpower availability related to CNC thermal cutting indicate several concerns. The availability of skilled manpower is rated predominantly as 'Poor,' while the education level of employees or students is viewed more positively, with 'Good' receiving the highest rating. However, the availability of general manpower is again seen as lacking, with 'Poor' and 'Fair' being the most common responses. This suggests that while education levels are satisfactory, there are significant challenges in finding both skilled and general manpower in the CNC thermal cutting sector. Employee retention for CNC thermal cutting operators is another area of concern, with 'Sometimes' being the most significant category, indicating occasional retention issues. The 'Often' and 'Always' categories also show notable portions of frequent retention, but the presence of 'Rarely' and 'Never' responses highlights that some employers struggle significantly with retention. The ease of replacing CNC thermal cutting machine operators is predominantly rated as 'Moderate,' suggesting that it is neither particularly easy nor difficult for many employers. However, a significant portion finds it 'Difficult,' indicating challenges in finding replacements, while very few respondents find it 'Very Easy.' Finally, the role of

educational institutions in CNC thermal cutting is limited, with 'Never' being the highest response for institutions offering programs, students getting practical exposure, and vocational schools providing specialized training. This highlights a substantial gap in educational support for CNC thermal cutting, suggesting a need for increased focus on developing and offering relevant programs and training.

5.2 Discussion on question 3

The age distribution data of the 80 respondents reveals a higher representation of middle-aged and older adults, with the largest segment (32.5%) falling within the 40 to 50 age group, followed by 31.3% in the 50 to 60 age bracket, and 28.7% in the 30 to 40 group. The smallest group, comprising 7.5%, consists of individuals aged 21 to 30. This distribution suggests that the surveyed population predominantly consists of experienced professionals, likely contributing significant industry knowledge and stability. The gender distribution shows a striking imbalance, with 98.8% male respondents and only 1.2% female, highlighting a pronounced gender disparity. This could indicate potential gender biases or barriers within the surveyed context, underscoring the need for targeted efforts to promote gender diversity and inclusion. Geographically, the majority of respondents are concentrated in the western (37.5%) and northern (33.8%) regions of India, while the southern, eastern, and central regions are less represented. This suggests regional disparities in industry distribution or survey outreach. The industry type distribution reveals a predominant representation from the fabrication sector (88.8%), indicating a significant focus on this industry. Organization size varies, with the largest segment (43.8%) consisting of medium to large organizations (100 to 500 employees). This varied distribution reflects diverse organizational contexts, particularly favoring manufacturing roles, which dominate the respondent roles at 95%. Overall, the data highlights significant demographic, gender, geographical, and industrial patterns that warrant further investigation to address disparities and promote balanced representation. In the words of Ho Chi Minh “To reap a return in 10 years, plant trees. To reap a return in 100 years, cultivate the people ” which directly applies to our subjective challenge indicating that a lot needs to be done with the younger generation. The disarray in distribution of potential can be related to long term employed high skill respondents compared to the lower skilled in line with the data studied during our literature review. As mentioned by Cappelli , shift in the composition of the work force toward higher-skill production jobs contribute a smaller amount to the overall rise in average skill requirements . Mentoring is the key deliverable one can expect from professionals who can provide the pathway to identification and nurturing of skills with a feedback system in place. They can also offer practical perspectives and suggest areas of improvements. You can find mentors through professional training or through team-work in an organisation.

Learning is a continuous process and employees should necessarily continue their Professional development. This can include taking advanced certification courses and become members of recognised professional bodies in this area. Eg : AWS (American Welding Society). Skill development can benefit both individuals and organizations in multiple areas. Some of them are as under;

Improved involvement: When you have the knowledge and skill-set, you can add more value to your work.

Financial progress: Companies often offer additional compensation to employees with updated skills and expertise.

Productivity increase: This is a result of training and self-development.

Raised living standards: Better financial compensation directly improves buying power.

WinWin: Employee development is directly proportional to the organizational growth and prosperity.

Experienced professionals in Industry, educational institutions and governments, may look at the focus areas of development as suggested above in detail and with open approach. Businesses are more and more relying on information to make strategic decisions. This process is inevitable and fast adaptation is need of the hour. Skill sets are handicapped without proper data management and analysis. It is becoming more and more important identify the employee who can understand and work with data. Number crunching skills are necessary in today's perspective. Training on Excel, Google analytics, Tableau etc. or any other tool which has synergy with the organizational business model has to be identified and implemented. Digital culture and AI exposure is becoming an essential requirement for the future. Its not surprising that everyone wants employees with updated digital skills. AI has come like a Tsunami and has now become essential in every sector. Its finding use even in areas like programming skills engineering drawings and manufacturing processes etc . The demand for this skill is high and also offers better financial benefits. According to the conference of state bank supervisors' cybersecurity is another knowledge area which is now becoming important. Loss or theft of information causes damage to the organization. Since, external agencies providing these skills are expensive, more and employers are now looking to develop in house skills in this area. Employees who can't handle these challenges will slowly become liabilities. Imagine an employee who is making cutting plans for a project in the shopfloor and the same goes into the hands of a potential competitor. This amounts to loss of intellectual propriety gained over many years of experience.

The business-world is dynamic. The last few years saw challenges like and the Covid pandemic, Adaptation id going to be a major skill. Critical skilling and troubleshooting abilities are keep things are necessary smoothly. All organization's need reliable people who can handle anything from delivering output to fixing problems and to effectively communicate and get the job done.

One important area of human psychology has emerged due to these new challenges is EQ. As already mentioned, emotional quotient (EQ) is the ability to understand, use, and manage your and others emotions effectively skillfully . Today's employees are better read than in the past . Toxicity at work-places is not welcome . Managers , Co-workers need training in respectful and widely acceptable levels of communication. Cross-cultural adaptations are becoming important due to collaborations , technology transfer and overseas training etc . These skills essentially include knowledge of cultural differences, foreign languages (conventional as well as technical) . Linguistic barriers happen when people speak different languages and misunderstandings arise out of the same. Body language such as hand

gestures, facial expressions, loud communication etc also pose challenges .Value systems are different in different regions during discussions. It is observed that the value of time or money or acceptable quality standards etc can lead to major conflicts. Addressing these challenges help build trust.

5.3 Discussion of Question 4

The data reveals a significant gender imbalance among the respondents, with an overwhelming 98.8% being male and only 1.2% female. This pronounced disparity suggests that the survey sample is predominantly male, indicating a potential gender bias in the context from which the survey respondents were drawn. Such an imbalance could be reflective of broader industry trends, where certain sectors, especially those involving fabrication and manufacturing, may have historically had a higher male representation. This gender disparity highlights the need for more inclusive outreach and recruitment strategies to ensure that future surveys achieve a more balanced gender representation. According to an interesting study quoted by us ,there is a lack of motivation among the young people to pursue a career in shopfloors. The numbers opting for vocational studies are still 10 times lower than the target . He adds there is a need to convince both young people and their parents that there is a lack of understanding of what manufacturing facilities look like today. They need to understand that this is also a high-tech industry that enables people to work with computers and build rewarding careers. Addressing this issue is crucial, as it may affect the generalizability of the findings and overlook the perspectives and experiences of female participants. Moreover, understanding the root causes of this imbalance, such as workplace culture, recruitment practices, or industry-specific barriers, can inform targeted interventions aimed at promoting gender diversity. Future research should explore these factors and consider implementing strategies to encourage greater female participation, thereby enriching the data with diverse insights and ensuring a more comprehensive understanding of the industry dynamics. This approach will not only enhance the validity of the research but also contribute to fostering genderequality in the workplace. As per Charlesworth and Banaji the engineering industry has more men than women because historically, engineering has been seen as a male-dominated field . In addition , lack of role models is one of the causes . The Indian society has deep gender bias when it comes to STEM (Science, Technology, Engineering and Mathematics education leading to barriers, due to reasons like costs , location and rigid conservative family values .

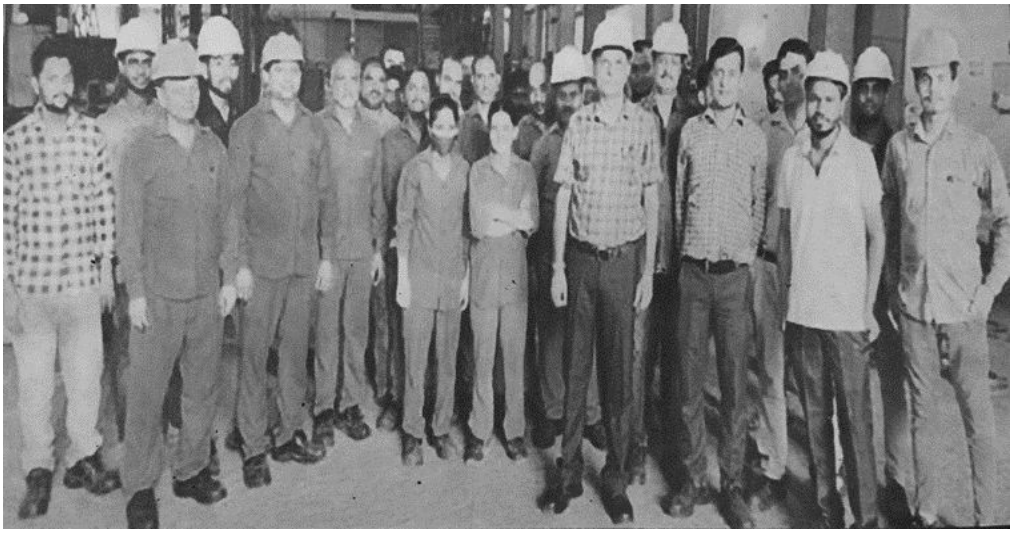
Across the world, there are more men who are active in science, technology, engineering and medicine (STEM) than women . Research shows that when men and women apply for jobs — be in the labour market, or in places where high level qualifications are demanded, men candidates project themselves well while equally qualified women are more modest in their representation . In meetings and discussions that happen in the Engineering industry , views of women are given lesser weightage causing self doubt and lower confidence levels among women. India's government is encouraging the **"Make in India"** initiative to support local manufacturing. Some companies are going one step forward to "make in India" solely with women initiative .Some manufacturing companies have announced that some of their assembly lines are being run entirely by women in an effort to increase gender diversity in the workforce (Anand , 2020) . Textiles , tobacco , food products , fire crackers etc have

traditionally hired women to work in manufacturing in India . Elgi Equipments, a maker of air compressors, said three of its assembly lines in the south Indian city of Coimbatore are now being run by women. Jairam Varadaraj, Elgi's managing director, said the company made a concerted effort to bring more women to the shop floor to benefit "from their different thinking," which in turn makes business decisions and outcomes more robust. "What's good for the business has to be done first," according to Varadaraj . Tata Group has also started encouraging women to undertake shopfloor related jobs. Assembly lines of car models Tata Harrier and Tata Safari are operated and managed by women. During our research , we visited the shopfloor of Spray Engineering Devices ltd (SEDL) , Baddi , HP state . We found that women are operating the CNC plasma cutting machines (See Fig 5.1 and Fig 5.2). A good number of welders are also women. Although women comprise of half of the Indian population , only 20 to 25 % are working women (Anand, 2020). India lags in this area. The reasons have already been discussed in detail above. According to research done by the Centre for Economic Data and Analysis (CEDA) at Ashoka University located in the National capital region at Sonepat , Haryana women comprise of 18 to 22 % percent of India's factory work force . The constituent ration is stagnant at that level since the last 18 months .The Elgi , Coimbatore formula was simple. They devised their own skill development courses , hired girls from nearby villages and trained them.

Fig 5.1 Woman operating CNC plasma cutting machine

Source: SEDL, Baddi

Fig 5.2 Women as part of work-force



Source: SEDL, Baddi

The company assured jobs after successful completion of training. As per the management of Elgi , they overcame the societal hurdles and successfully created a woman talent pool who consequently also earned decent salaries which encouraged their families to continue the support for such an initiative. Needless to say , the employers like Tata also adapted their internal infrastructure to suit women . Introduction of robots
, altering workstation heights etc are some of the changes. Tata management shared that they have employed over 4000 women in their various factories. The company is also sensitive to the day to day needs of women , especially those with children , pregnancy etc and provides official transportation to ease their day to day commute.

5.4 Discussion on question 5

The maximum respondents belong to Western India. The region comprises of Maharashtra, Gujrat & Goa states respectively. Mumbai, the financial capital of India falls under Maharashtra state. Gujrat state is known for maximum number of entrepreneurs. Goa has an Engineering based industrial belt but it is overshadowed by the Tourism industry. Maharashtra attracted an FDI of approximately US $15 Billion during financial year 23 -24 and Gujrat attracted around US $ 7 Billion . According to Melissa Cyril in her article on India briefing , the total FDI amounted to more than US $ 40 Billion .The results of our survey fall in line with the statistical data. By definition, we state that constraints refer to the available manpower, training institutions, industry focus, finance and logistics as defined by the Federation of Indian chambers of commerce and industry . It is essential to examine the areas which could be preventing statewise goals and objectives. The infrastructure & construction industry consumes around 40-60 % of total steel produced as quoted earlier in our study.According to Invest India formed in 2009 which is an institution engaged in promotion of foreign investment in the country ,western India has many industrial opportunities, including in the states of Maharashtra , Goa and Gujarat: Maharashtra state constitutes 18 to 20 % of the national automobile manufacturing segment. This includes vehicles as well as automotive components . Additionally , India's chemical production , electronics , Food processing ,

Energy sector . Information technology , Steel processing etc also find major investment in this state . Gujrat is known for mainly Refineries , Ports , Textiles , Pharma sector , Packaging and Power sector. Steel processing also forms an important part of the industrial activity. Goa is mainly known for food processing and tourism. There is also an industrial belt in Goa . Maharashtra has always been the first choice of domestic and foreign investors and contributes approximately 15 % towards the nation economy according to the Maharsahtra state industrial dev. It has been the reflection of India's growth for decades. Being the biggest contributor to India's GDP, Maharashtra state has always been number one contributor towards the Indian economy with excellent road , rail and air connectivity infrastructure , surplus power and investor friendly policy . Our research is supported by a recent article by Community Enabler Sidharta Roy , published in the Times of India newspaper on Maharashtra state and why it is a preferred investment destination .

The state has very detailed documented policy guidelines . The policies are investor friendly , enable competitiveness and supported by a strong regulatory framework . The state focuses on providing employment to its residents and boasts of a skilled work-force. Mumbai the capital of Maharashtra state is the National financial capital. The availability of natural and other valuable resources are the strength of this state. The state governments are supported by expert teams who advise on thrust areas. Documentation procedures and evaluation follow a transparent process. This helps building trust and long term relationships. The infrastructure network of the sate provides connection to over 300 industry parks with 5 international and over 10 domestic airports . There is good road network, and a long sea-coast facing the Arabian sea with more than 45 ports. High level of cargo transport with efficient logistics support is part of the support infrastructure. Maharashtra's is supplemented through regular exhibitions and knowledge seminars , webinars etc . The state also has over 25 National Accreditation Board certifying bodies (NABCB) to ensure a "quality first " approach. Employable talent constitutes 70 % of the work force and policies are labour friendly. Tax holidays and special exemptions on duties are also provided according to the merit. Digitally literacy and modern education makes the work force one of the best in the country.

Gujarat state is one of India's important manufacturing destinations and offers attractive investment opportunities . The state's appeal is underscored by frequent updates in industrial policies, export promotion schemes, and incentives for foreign investors in niche sectors. Gujrat boasts of a well-entrenched population of original equipment manufacturers and successfully running MSME initiatives . There are well documented provisions for Tax holidays , Special economic zones and Export promotional schemes . Their contribution towards national economy stands at approximately 10 % and they were the first state to implement the "Single Window " concept . They form the economic backbone of India in areas such as oil – gas , precious stones (over 75 % of India's diamond exports) , ceramics, textiles and high value capital goods .Additionally , processing of steel viz. heavy engineering and dairy machinery form important constituents of their strength. The state also is home to the highest number of entrepreneurs .

In summary, Gujarat offers a fast paced environment conducive for business operations with a wide spectrum of industrial opportunities , high potential infrastructure for export , and

skilled workforce All the above supplemented with strategic vision and excellent road a, rail and air travel facilities makes the state an attractive destination for industrialisation . Gujarat has received foreign direct investment of over US $ 7 billion last financial year . This is a 50 % plus jump over the previous financial year . This puts them at second spot in this category nationally . Maharashtra stands on first spot at approximately US $ 15 billion . Trailing the are the states such as Karnataka, Telangana and Delhi . The political leadership in the state is particular about ensuring "Ease of doing Business" model . Gujrat introduced concept of Gujrat international finance Tech city (GIFT) and Special investment region city (SIR) . The major objectives include attracting global investments, financial support, provide legal framework and technology and digitization driven. This was conceptualized in 2015 . As already, mentioned, they are a one stop solution for financing options, technology know-how, forex services, approvals etc to facilitate smooth operations. SIR locations are identified at Dholera, Palanpur, Valsad, Vadodara, Bharuch and Surat cities. These locations will play pivotal role in creating world class infrastructure with an eye on high prestige projects such as semiconductors, wind energy farms, nodal connections to main expressways, sea-ports, airports etc. Additionally, tax subsidies, lower cost of finance, land, power availability and fast processing of paper-work to establish base in Gujarat are few of the support initiatives provided.

The state of Goa is known for tourism, food processing, information technology and enabled services, Biotech engineering, drugs and pharmaceuticals and fishing industry according to the Indian brand equity foundation (IBEF). Goa is located in the western region of India. The state is based along the west coast Arabian Sea bordering with Maharashtra state towards the the north and Karnataka state at its south and the east regions. Goa coast is approximately 100 km in length connected to creeks, rivers amounting to over a 200 KM connected waterway branch network. Iron ore and Manganese ore mining is another sector followed by ship-building. Goa is now pushing itself as a manufacturing hub for electrical and food processing machinery. Investments in Cement and Agro industries is also seeing a gradual rise. The stage has good road, rail connectivity and 2 airports.

5.5 Discussion on question 6

We interviewed key personnel from manufacturing units covering areas such as Steel fabrication and machining. Importance was also given to vocational training institutes followed by traders and site contractors. Manufacturing units provided us with maximum data. We observed that the engineering fabrication plays an important role in our research. As already discussed earlier , Steel has to be handled , cut , welded , finished to form assemblies , sub-assemblies which are used to create national infrastructure comprising roads, bridges , flyovers , power and other process equipment etc . Skill sets required are also maximum in the area of fabrication. Our research is in line with the same. CNC Thermal cutting is the key activity in this process. Our study reflects the actual field conditions and provide field personnel with an insight towards identifying and managing the identified constraints . Steel fabrication and infrastructure development in India are closely related, with the steel fabrication industry playing a critical role in the country's economic and infrastructural development: The Indian structural steel fabrication activity is expected to increase exponentially to meet the demand due to national infrastructure growth.

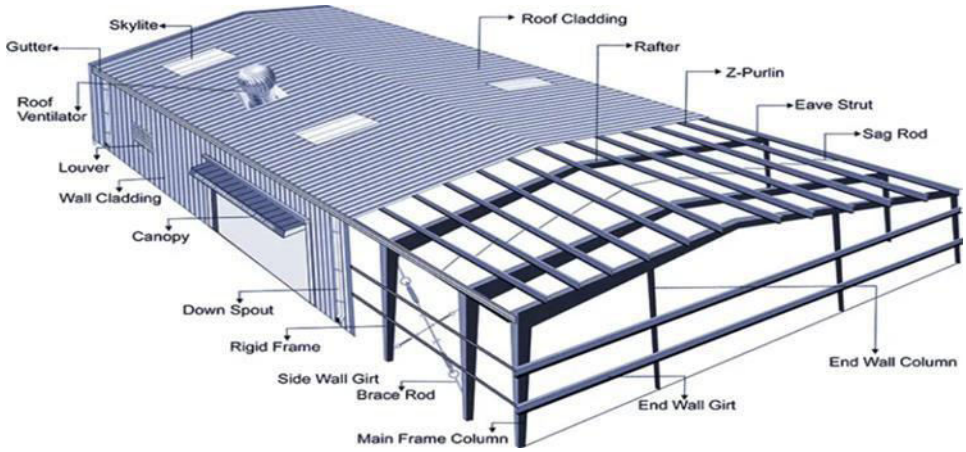
Construction segment absorbs over 60% of the total steel consumption in India. Steel used in infrastructure building mainly comprises of steel structure fabrication and roll-forming . Our research is in the area of steel fabrication. Structural fabrication is divided into 2 categories;

Light Pre Engineered building structures

Heavy structures used in bridges , power plants , flyovers etc

Pre-Engineered Steel Buildings concept is very popular with multiple advantages and in accordance with present industry demands . This technology has virtually eliminated the need for reinforced cement concrete (RCC) . The load bearing structures consist of fabricated steel girders . This technology is modular refer fig 5.3.

Fig 5.3 Pre-engineered building

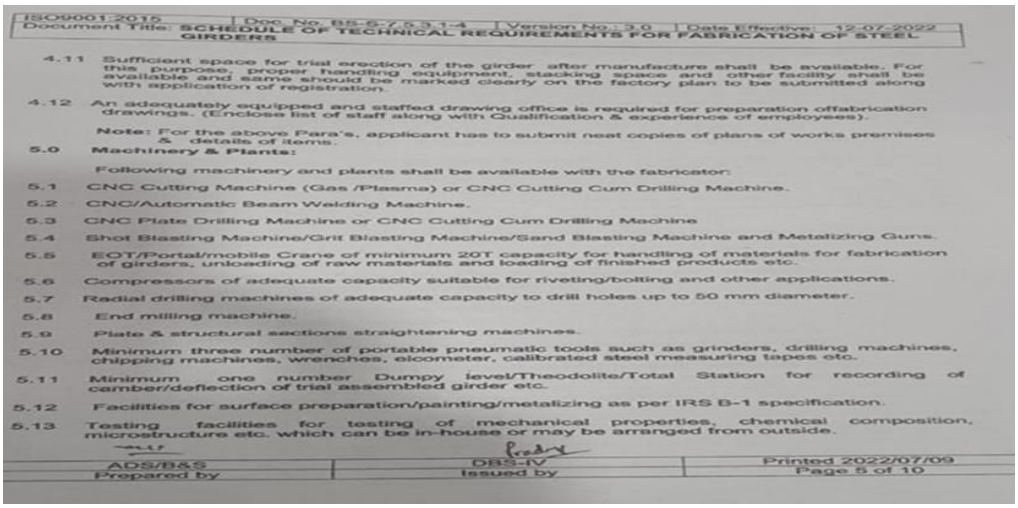


Source : Gondal group , Pakistan

According to M.Abrar of Gondal group , they are manufactured using dedicated design and manufacturing software which takes into consideration the structural engineering , bill of material , estimation , costing and aesthetics .The primary load bearing components are steel girders . These are supplemented with roll formed sections that act as roofing , piping , purlins etc . Partitions are usually made of sandwich panels which have insulation material between two roll formed sheets . These are light , easy to assemble and exhibit good environmental and weather related protection . They also add to the aesthetics. Further , modular accessories form doors, windows, vents ,natural lighting etc . The modular approach ensures easy assembly at site and fast construction . Material optimisation ensures lower costs and less requirement of skilled labour. These structures are durable and long lasting , thus providing a higher factor of safety. Since design is generated by software , there is a lot of flexibility possible while finalising the architectural details . Industrial workshops , high storey buildings , warehouses , hangers , logistics centres , IT parks , Petrol pumps , Bus stops etc are all switching over to this type of construction technology. The major challenge in this field is the smooth availability issue and fluctuating prices of steel . The per capita steel consumption in India has grown from approximately 50 Kg to 70 Kg since 2019 . It is estimated that rural India steel consumption will double in next five to six years . All this amounts to a very high level of steel processing . Needless to say , the heart of the process here is CNC thermal cutting. Heavy Construction fabrication primarily involves Railway bridges , Flyovers etc. The primary standards are fixed by certifying organisations like RDSO (Research design and standards organisation)

which is part of Indian Railways . The railway bridges require heavy duty girders confirming to critical safety standards. These are fabricated in a workshop and then finally assembled at site . The manufacturing operations cannot go ahead without CNC thermal cutting of steel. RDSO has clearly outlined that the manufacturer should have the CNC thermal cutting (Gas , Plasma process) in order to qualify for Railway infrastructure tenders . Figure 5.4 shows the essential equipment , part of qualifying criteria specified by RDSO . Without this infrastructure , a manufacturer cannot qualify to participate in the Railway infrastructure tenders .

Fig 5.4 Capex list for qualification,



ISO9001:2015 | Doc. No. BS-S-7.5.3.1-4 | Version No.: 3.0 | Date Effective: 12.07.2022
Document Title: SCHEDULE OF TECHNICAL REQUIREMENTS FOR FABRICATION OF STEEL GIRDERS

4.11 Sufficient space for trial erection of the girder after manufacture shall be available. For this purpose, proper handling equipment, stacking space and other facility shall be available and same should be marked clearly on the factory plan to be submitted along with application of registration.

4.12 An adequately equipped and staffed drawing office is required for preparation offabrication drawings. (Enclose list of staff along with Qualification & experience of employees).

Note: For the above Para's, applicant has to submit neat copies of plans of works premises & details of items.

5.0 **Machinery & Plants:**

Following machinery and plants shall be available with the fabricator:

5.1 CNC Cutting Machine (Gas /Plasma) or CNC Cutting Cum Drilling Machine.
5.2 CNC/Automatic Beam Welding Machine.
5.3 CNC Plate Drilling Machine or CNC Cutting Cum Drilling Machine
5.4 Shot Blasting Machine/Grit Blasting Machine/Sand Blasting Machine and Metalizing Guns.
5.5 EOT/Portal/mobile Crane of minimum 20T capacity for handling of materials for fabrication of girders, unloading of raw materials and loading of finished products etc.
5.6 Compressors of adequate capacity suitable for riveting/bolting and other applications.
5.7 Radial drilling machines of adequate capacity to drill holes up to 50 mm diameter.
5.8 End milling machine.
5.9 Plate & structural sections straightening machines.
5.10 Minimum three number of portable pneumatic tools such as grinders, drilling machines, chipping machines, wrenches, slcometer, calibrated steel measuring tapes etc.
5.11 Minimum one number Dumpy level/Theodolite/Total Station for recording of camber/deflection of trial assembled girder etc.
5.12 Facilities for surface preparation/painting/metalizing as per IRS B-1 specification.
5.13 Testing facilities for testing of mechanical properties, chemical composition, microstructure etc. which can be in-house or may be arranged from outside.

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Source: RDSO, India

5.6 Discussion on question 7

Organization sizes were considered important for our research. The aim is to analyses who can adapt to changes in environment and who has resources to do the same. We classified organizations into small (below 50 employees) , small medium (between 50 to 100 employees), Medium (100 to 500 employees) & large (500 and above). We learnt that large organizations have huge costs. As emphasized earlier ,a strong infrastructure is necessary for any manufacturing sector to grow .The government of India is investing sizeable level of funds towards building a strong network of roads, rails and transport to foster the growth of the manufacturing sector .Our requirements of skill towards processing steel are also getting complex .Adaptability to change is now a prime requirement. We are aware that the major activity in infrastructure development is steel fabrication. Steel Fabrication is however considered generic and at the lower end of a value chain. Large organizations prefer to sub-contract this activity to focus more on supply chain management, design and development, software support etc. When it comes to producing a standardized quality and offering a timely delivery, the organization is expected to have the necessary machineries, manpower and finance. Among the important machinery meant for fabrication, CNC Thermal cutting machines command highest priority. Our respondents agreed that unless steel is cut, no other operation could be carried out. Keeping in view the prime movers like machineries, manpower and finance, medium size organizations appeared most qualified as per this research. Maximum responses were also received from this segment. The business model of these organisations leads to some observations. Clear goals were top on the list. The organization had clear hierarchies documented in their systems. All

were ISO certified and had clear processes and procedures for tasks and their outcomes. Work-force were disciplined and had clear job description. These organisations also believed in job rotation in order to avoid stagnation or creation of fiefdoms. There was a strong emphasis on planning and facilitation of tasks which enabled tracking of progress and address any emergencies or non-conformities. We also laid emphasis on organisational adaptability. This refers to level of flexibility to adjust to the changing business scenario to achieve targets. This depends mainly on the leadership and work-culture according to various studies conducted by universities as well as industry. Organisations have come forward and introduced incentive schemes for flexibility related schemes , skills development programs to compliment the same . The organisation should be fighting fit and able to make fast course corrections in strategy. Research conducted by the University of South California , identified the hurdles in this process. Being open to multiple perspectives is an important factor. Humility in leadership helps translate the organisational objectives informally than the traditional "top – down autocratic approach . Job security emphasis also was found to be an aiding factor. Being transparent about the short and long term goals , building an environment of trust , receptiveness to different view points and encouraging a critique and empowerment of employees were among the other important conclusions. The net result observed was the increased resilience among employees and team-work

5.7 Discussion on question 8

We have covered the important points in the results section. We are now aware that CNC Thermal cutting process is key part of the manufacturing process. Manufacturing activity takes the front seat in infrastructure building. Our respondents were extremely clear on this point. Inspite of having the highest participation in our survey , data from the World Bank indicated that in 2013, the contribution of manufacturing sector to Indian Economy was lesser than 15 %.

5.8 Discussion on question 9

The Indian government is investing on the "Make in India" program since 2014 . There are many government programs focused on promoting local industry . This is encouraging however , it has been observed that there is a huge disconnect between the policymakers and the departments down the line who are expected to implement the policies . Land allocation along with clear property titles , local group resistance , labour laws , power , water , accessible roads and environmental clearances form a huge mechanistic hurdle which causes long time delays and dropping levels of motivation to move forward . Many entrants are unaware of these challenges and fail eventually. Through exhaustive interactions carried out during our research, the respondents did agree that it was possible to get skilled personnel. They mentioned that the cost of these personnel were extremely high. A major section also argued that availability of skilled people is a major issue. These two results have to be seen in totality and not in isolation. It becomes increasingly evident that those who cannot afford are badly affected. Our results show that this section is equally dominant like the highest section. The only solution that was found acceptable was to increase the talent pool of skilled people. We had highlighted that only 2 to 3 % of the workforce in India have undergone formal skill training as compared to 70 % in the UK, 75 to 80 % in Germany, 50% in USA, 80 to 90 % in Japan and almost 95 % in South Korea .The research also showed that general personnel availability is not a challenge. We observed that general education level of prospective

employees was good, however they lacked in vocational training,as quoted earlier which is in line with our observations. There is scope for improvement. Infosys – Business process management (BPM) has identified 6 pain areas in manufacturing which are **labour supply** (getting the right candidate) ,**inventory management** (slow moving inventories causing fund blockage and long lead times of essential inventories) , **poor forecasting abilities** (poor prioritization leading to every activity becomming important and exposes unpreparedness) , **inertia and resistance towards automation** (primarily due to job insecurities) ,**operational inefficiency** (a result of resistance to change and getting trapped in comfort zones) , **ignoring the changing trends** related to technologies (organizations still depending upon historical data and traditional practices) .

5.9 Discussion on question 10

Almost all the organisations we studied during our research concurred that , the major challenge in today's competitive world is the retention a skilled workforce. Broadly , organisations face two types of customers , namely the internal and external customers (Duncan , 2024). Here , we are referring to internal customers who are the employees of the organization. Retaining both is important for business growth , profit and sustainability. Organisations have to identify the potential employee and invest in their development and create the roadmap for their progress. The financial compensation to match updated skills will strengthen the loyalty . The process ideally starts from recruitment. Several factors such as location , family background , health etc play important roles. Investment in technical training and management training helps the employee evolve to ownership levels . This helps building a strong bond with the organisation and brings an accountability culture. Identifying oneself with organisational success builds a long-term association. Organisations have to also deal with job hoppers and poaching by competitors. This is a day-to-day challenge . Fundamentally , following the established techniques mentioned above will be helpful. During our interaction with Spray Engineering devices , Baddi , Himachal Pradesh state , we observed that the company provides three meals a day per shift comprising breakfast , lunch and evening snacks to every employee. The canteen is common for all levels of hierarchy. Additionally, the company makes a fact check with previous employers before hiring a new employee . New employees undergo an extensive orientation program to familiarize themselves with various departments . Attrition rate is below 5 % and considered better than industry standard as per their management . They follow a flat hierarchy structure and top management personnel are easily accessible to employees of all levels. The company is in process of establishing a " **State of Art - Centre of Excellence** "which plans to impart technical and management training for all the employees depending upon the assessment of their skills made by the human resources team. Above points provide a summary for the various points discussed . They indicate what managements should not do , how to motivate and retain employees and characteristics of top performing teams and employees.

Our respondents mentioned that CNC Thermal cutting machine operators were considered extremely important in a manufacturing unit. Thermal cuttings the first activity and feeds the subsequent operations.

Most companies we checked had minimum two operators per machine and they worked in

shifts. Retaining the operators posed a huge challenge to employers. Most of them are always in demand in similar organizations. Increased infrastructure growth means increased work leading to greater employment opportunities. “Poaching ” the skilled operators by offering higher salaries is very common. Some organizations resorted to providing compulsory saving schemes, retirement benefits, medical insurance and child education funding etc to keep skilled people happy. Small organizations have no protection and work under stress fearing attrition. Paying more is not a workable option for them. We had observed the lack of motivation among the young people to pursue a career in shopfloors . The numbers opting for vocational studies are still 10 times lower than the target. According to CMIE , this is also a high-tech industry that enables people to work with computers and build rewarding careers. India has a 140 Billion plus population, 25 % population below 35 yrs age and over 50 % population below 25 yrs age makes a valid point for opportunities available and future potential to become a strong global manufacturing hub .It is unanimously felt that ,creating a better link between industry and vocational institutes aimed at churning out large number of skilled personnel is the best solution.

5.10 Discussion on question 11

We have discussed the essence of this question, already in discussion on question 10.

5.11 Discussion on question 12

Our research revealed an alarming fact that Vocational institutes do not offer CNC Thermal cutting related courses. This situation has to be corrected immediately. Respondents were unaware that CNC Thermal cutting is the backbone of steel fabrication industry. They were Theoretically aware of gas cutting process and limited knowledge of plasma cutting process. None of them had any knowledge of the extensive use of laser cutting automation being deployed in the engineering fabrication segment. This situation calls for action on a war footing. Since these subjects were not part of the curriculum, it was obvious that the related machineries were absent. This indicated lack of theoretical as well as practical studies. We did come across two respondents who had arranged industrial visits for students. Overall, the situation is not good. We came across one private initiative near Jaipur (Bharatiya Skill Development Institute) who had invested in different plant and machinery, designed skill development courses in the area of machining. The National Skill Development Corporation (NSDC), comprising distinguished technical professionals is in process of setting up industry- specific skill councils. The aim is to focus on skill development through public- private-partnerships (PPPs). Industrial zones in India require different skill sets depending on the dominant industry in that region. Lets say , Faridabad in India depends mainly on JCB who manufacture backhoe loaders and most industries are engaged in producing assembles and sub-assemblies for JCB ‘s final product . When we looked at Tiruchirappalli area , the dominant industry is windmill tower manufacturing and heavy engineering . Tiruchirapalli zone has taken initiative and formed an institution called TREAT (Tiruchirappalli Engineering and Technology cluster) . Figure 2 shows their setup located in the state of Tamil Nadu , South of India. The cluster provides high precision metal processing and heavy engineering machining facilities . TREAT was established in 2014 . This is a non-profit organisation supported with the funding assistance from Department for Promotion of Industry , Internal Trade (DPIIT), Ministry of Commerce ,

Government of India and the Industrial association in Tiruchirappalli. . TREAT has also signed a strategic alliance agreement with Tamil Nadu state industrial development corporation (TIDCO) for participation in the initiative.

Fig 6.3 TREAT cluster

Source : www.treat-trichy.in

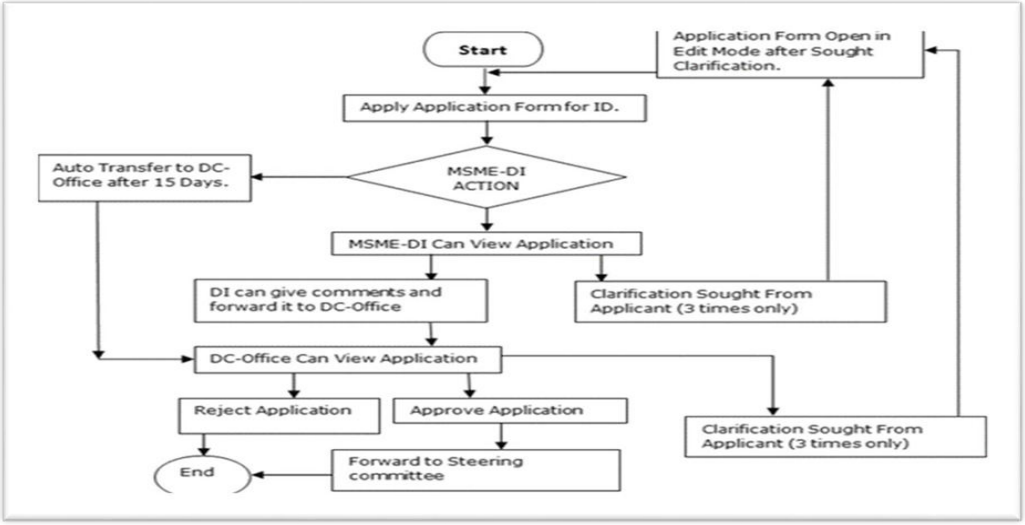
The project was developed in the suburban area close to the national highway. The total space allotted is approximately 60000 sq. meters comprising the "State of Art" machineries in 3 large workshops. The facility covers fabrication , machining , shot blasting and painting systems. The unit is used as a common facility by the industries in that zone , additionally also provides training to prospective candidates to equip themselves with the knowledge to become employable .Facilities such as Heavy Plate Rolling/Forming , CNC Laser Cutting, CNC Gas cutting , Dish-end press , Precision machining and Heat Treatment Facilities are not possible for individual companies to invest . Most companies have limited facilities . They use the unit for getting their jobs done as well as train their existing employees and apprentices who then act as the back-up force in the organisation. This helps create talent pool and lower dependence on limited skilled individuals

1. The Facilities they have are as under ;
2. Vertical Turret lathe (VTL)
3. Horizontal Boring machine
4. Machining centres
5. Horizontal Drilling machines.
6. Radia Arm drilling machines.
7. CNC laser cutting machine
8. CNC gas cutting machine
9. Plate roll-bending machine.
10. Dish-end forming machine
11. Spinning and hydraulic flanging machine .
12. Blasting and Painting facility
13. Overhead cranes

14. Hydra type cranes
15. Coordinate measuring machine

In addition, the Ministry of Micro, Small and Medium Enterprises (MSME), Government of India (GoI) has also adopted the "cluster development " as an important strategy for strengthening the productivity and competitiveness of Micro and Small Enterprises (MSEs) and address the various zonal challenges . The goals of this initiative are described as under: The major focus is aimed at technology and skills upgradation. This is supplemented with local industry cooperation and encourage the common facility concept to grow zonally . Figure 3 outlines the process followed towards implementation of this scheme.

Fig 6.4 Flow of the MSME Cluster Scheme



Source: MSME website

Industries are further classified as Micro, Small and Medium according to their sales turnovers. Micro means approximately US $ 600000 per annum or below , small means approximately US $ 6 million or below , Medium means US $ 30 million or below . Each of these categories are funded accordingly . The maximum aid is limited to approximately US $ 6 million . Their key functions include , financial assistance , adoption of latest technologies , strengthen the zonal capabilities thus giving opportunities to compete nationally and globally , promote the cluster based promotional scheme , provide marketing support , encourage skill development and facilitate self – employment under various enterpreneural schemes. " Industry-standard modern machines and tools are installed at the COE are further sharpening our student skills ", says Er Sabitarani Sahoo, Principal, and Government ITI Jajpur. Trainers and students from various Government ITIs across the state come for training at the COE on "Thermal Cutting and Welding" at Government ITI Jajpur. During the academic year 2022-23, students from government ITIs in Bhubaneswar, Pattamundai, Berhampur and Barbil came here in 6 batches for training. In 2023-24, 20 such batches are targeted for imparting advanced training in 'Thermal Cutting and Welding'. Along with training in respective trades, the Govt ITI Jajpur also imparts necessary coaching to students on successfully navigating placement interviews in their respective fields. Additional training programs for students are also conducted at the ITI in collaboration with various industrial institutes. OMBADC has also provided financial support for the development of additional

infrastructure at Government ITI Jajpur. Efforts have already been initiated to establish additional 1500 Industrial training institutes and over 4500 skills development centers through the PPP mode. The new policy is also expected to set standards for competency-based qualifications and certificates on national- approved criteria. The NSDC, ITIs and polytechnics are expected to substantially increase their training capacities over the next decade to achieve the target of equipping/training over 500 million people within the next 3 years**.**

5.12 Discussion on question 13

Attrition is a burning issue and on the rise in the manufacturing industry today . Attrition in our context is attributed mainly to employee resignations .though it is also an equally important issue when skilled people retire or die during the tenure of their employment .When a skilled ,trained and loyal employee leaves the organisation, it leaves an irreparable void losing precious skills, know-how and critical associations. Reducing attrition in an organization is an important focus area and an on-going activity today . Retaining workers is a concern for any business, but metal fabricators face some unique challenges. Because the industry requires specialized skills, there is a shortage of workers who have the necessary experience to meet shops' needs. The physically enduring nature of the activities involved ,discourage people from opting for a job in the metal fabrication industry . Exposure to noise , radiation , fumes can be compelling factors towards this resistance. Employees have to work with heavy machineries and stakes are very high causing undue amount of stress among them. In addition, toxic work cultures added to the problem .Table 5.1 summarises this appropriately.

Table 5.1 Toxic management behaviours

Behaviours	**Impact**
Micro-management	Undervalueing , Trust deficit , No freedom
With-holding information	Anxiety and power politic
Seeing only R in HR	Time spent on non-value added work
Leadership as position	Authoritarianism and zero collaboration

Metal fabrication organisations face high attrition rates, as the workforce is always on the lookout for better working conditions , salaries and low amount of health risks . Many, also opt of careers outside manufacturing .To attract and motivate the workforce , organisations have to build a good reputation and address overall employee benefits . This may include implantation of safety standards , health insurance , retirement benefits , education loans for children , paid holidays and in some cases , cooperative societies to cater to subsidised priced day to day used products and loans with lower interest rates to meet miscellaneous requirements such as furnishing , marriage expenses etc . Companies like Larsen and Toubro ltd , India successfully retained their core workforce and implemented almost all the above suggestions systematically. Since there is always a deficit of skilled employees are offered specialised training courses linking it to growth prospects. There is always a give and take

involved. During our interactions with the industry respondents ,we found that some organisations make it conditional for the employee to sign a fixed period service bond in return for having invested in a specialised training course by the employer.

Companies also provide mentoring through experienced staff and encourage on the job training with job rotation policies. This enables the employee to learn new skills and the employer gets rid of monopolistic situations . Organisations according to Lisa Ryan , Founder – Grategy , USA need to maintain regular communication with employees and use a reliable feedback monitoring system ,appreciate and reward performing employees ,maintian a safety and health first policy , train on respectful communication and ensure its followed strictly and allow flexi hour working wherever possible . The organisation may also consider , disbursement of loans along with assistance towards easy repayment , offer mental health support , encourage corporate social responsibility(CSR) related activities , encourage and reward environmental related initiatives.

5.13 Discussion on question 14

The Indian workforce can be summarised as young , low on skills and mostly present in the informal economic sector . The Indian workforce will remain a majority in the coming years in stark contrast with the West which is dealing with an aging workforce . The world is now moving towards the next Industrial revolution (Industry 4.0) and there will be immense amount of focus on information technologies , automation and digitalisation in manufacturing. National Sample Survey (NSS) of India highlighted a decade back that over 30 % of our population was approximately under 18 years old and over 10 % were under 18 to 25 years of age. percent of India's total population are under the age of 17, and approximately 13 percent are between 18 and 24 years (Table 1). While over 41 percent of the population between 18 and 24 years are already part of the workforce, the others will be joining the workforce in the next two decades.

Table 5.2 Age Group classification among Indian workforce 2012

Age Group (in years)	Approximate Percentage of Total Population in Each Group	Approximate Workforce as Percentage of Total Population in Each Group
0-10	Over 30 %	3
18-25	Over 10 %	40
25-60	Over 40 %	60
>= 60	Below 10 %	30

Source NSS , 2012

Our research indicates that the workmen are mainly between 21 – 30 yrs age group. This group has been referred to by the respondents as youth . It is extremely important to note that CNC thermal cutting operations , maintenance and troubleshooting requires energetic people and those who are willing to learn the technology and new developments. We also find that age group 30 – 40 years are also not very far behind. The classification of work content and the

physical, mental endurance demands dictate which age group can be put in what activity. It was clearly implied that the latter group is usually experienced and have better aptitude for planning, economics and process control related work. 50 % of Indian population however is below 15 – 24 yrs age group.

The general conclusion as expressed by the respondents was that, this generation needs to be trained and made employable.Though we have a young workforce , we have already pointed out that only 2 to 3 % of employable population has undergone any form of formal vocational training . A deeper study indicates our unpreparedness for the next industrial revolution due to the knowledge-gap between existing and high technology manufacturing processes as they are highly capital intensive . Cost of finance is very high in India and wealth distribution is highly skewed.

5.14 Discussion on question 15

This section is self-explanatory. Detailed discussion in the area with various respondents revealed that referrals were the primary mode of getting prospective employees. The area that required attention were the vocational institutes who have to create talent pools for recruitment via campus selection mode and other modes. When it comes to hiring , a good job portal can make sizeable impact . Though are several job portals available in India , there are few key factors to take into account while scouting for skilled personnel or a job opening After extensive discussions with the industry respondents, the following suggestions were summarised ;

Listing: The database size and matching opportunities are covered here. The metal fabrication industry does not have a dedicated portal, and prospective employees or employers have to go through a long process of filtering to zero down on a suitable candidate or job opportunity. The process can be further streamlined with time-to-time alerts in the form of mails or SMS sent on mobile phones.

User-friendliness: An interactive system can simplify the search process. This enables less educated personnel to use the platform effectively. Additionally, language options will be an added advantage.

Employer, Employee Reputation, Background Check: These are essentially required to avoid scams and information checks.

Structured Resume Forms: This can help the screening process with the help of software that evaluates a candidate concerning the job description codes.

Career Counselling Services: One can book a time slot for a one-on-one discussion and clarifying doubts. This can also be part of premium services on the portal, which may not be free of cost.

Mobile Accessibility: Job portals on mobile phones can be very handy. People can use them easily. Over 1.5 billion mobile users in India and over 50% of smartphone users in India are in the 18–25 years age group. Refer to Table 5.3, which shows that India is ranked No. 2 in the world when it comes to the number of mobile phone numbers.

Table 5.3, Mobile numbers data

Country or regions		Approximate mobile
Rankings	World	**phone numbers .** Approx. 7 billion plus
1	China	1.6 billion plus
2	India	1.5 billion plus

Source : World population review , 2024

Industry-Specific Portals: Job or employee search based on the type of industry can add better value. They have a clear understanding of the dedicated requirements and job specifications of their specialized areas, which adds greater relevance to the subject matter.

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CHAPTER 6
SUMMARY

6.1 Why CNC Thermal cutting operations?

We have explained in detail, the importance of processing steel when it comes to infrastructure building. The steel plates have to be cut into shapes and sizes to fabricate structures and assemblies required for building the core infrastructure of a nation. India's formally skilled workforce is just 2% of the available population as previously pointed out. Additionally, there is a huge problem of employability among the educated workforce of the country. Lack of vocational or professional skills makes it difficult for the youth to adapt to changing demands and technologies of the marketplace. The high level of unemployment is due to the failure to get jobs and due to a lack of competency and training. There is a deep issue social bias when it comes to vocational training education.. Such biases find their roots deeply ingrained in society and needs to be addressed in order to create a more conducive environment. A major factor that acts as a hurdle in the Indian context are the exhaustive labour laws. Simplifying labour laws is a prime requirement .Obsolescence is a big challenge as well opportunity for the work force. Constant upgradation of skills is necessary for survival. There is a serious observation that current training institutes lack infrastructure .Another problem is the quality of instructors available. These instructors are unable to create an industry ready work force. Training the trainer is a key initiative that needs to be implemented on priority. Skills within the country have to adhere to a common and benchmark and it should not be below global standards .

6.2 What are the basic relevant skills that we look for in CNC Thermal cutting ?

These include machine operation (ability to run the machine and be aquainted with various operations) , adaptability (to be able to cope with the daily scheduling and process flexibility), maintainence (to be able to troubleshoot , diagnose and repair) and safety compliant (to adhere to all safety precautions). These , essentially comprise understanding the basic principles and structure of thermal cutting machines, and study the operating procedures , familiarising with the faults and solutions , acquire basic knowledge of cutting and processing , understand the metallurgical properties and cutting limitations / capabilities of various metals and basic computer operation and maintenance skills, and be ablility to use relevant software and tools to manage and maintain CNC thermal cutting machines . CNC thermal cutting machines are hi-tech machines. Machine operators need to grasp the basic operations methods ,working principles machine features , and be able to produce the desired output . The machines may call for timely repairs , hence necessary to maintain a record to identify and sort out problems easily. Fibre Laser cutting machines are high-risk machines, and operators need to adhere to strict safety norms to avoid accidents. Thermal cutting machines can harm eyes, respiratory tract , ears and skin mainly. The skills involve basic knowledge of; Material: Carbon steels , Stainless steels ,Titanium , Aluminium etc Gases used viz Oxygen: Acetylene or any other fuel gas, Nitrogen, Argon, Hydrogen Role of air: Operation of machine pneumatics, Air plasma cutting Process selection: Gas, Plasma or Laser cutting Thickness of raw material: Cutting range from 0.5 mm to 300 mm Gas pressures setting As per manufacturer recommendation Cutting speed settings :As per manufacturer recommendation Consumable selection :As per manufacturer recommendation Tool path selection: To ensure efficient time management Nesting: To ensure minimum scarp Data management: To schedule the cutting plans ERP link: To plan organisational target and inventories Descriptive details can be found in the texts related to the below descriptions Laser , Gas , Plasma cutting operations . Laser , Gas , Plasma Cutter Safety : Comprehensive Standards and Guidelines .

How to Avoid Accidents while using CNC Thermal cutting machines . Cutting of steel forms, the backbone of national and international infrastructure development.Steel cannot be cut effectively and quickly without thermal cutting processes. During the course of our study, we have focused on the examination of the skills for facilitating CNC thermal cutting operations to meet the infrastructure demand in India. It is very important that Industry and Academics should work together to improve the skills of the prospective work force. Key pointers that we kept in mind were related to geography, demographics, vocational education, attrition analysis, process followed towards recruitment and the motivational factors relevant to this study. We also touched important areas like the Cutting management during our study on Servitization & various Skill development initiatives present . To improve the supply and retention of skilled, job-ready workforce in CNC gas, plasma, and laser cutting in India , the following points will facilitate our goals ;

Enhanced government-funded vocational training programs: Government - academia may explore a relevant curricullum , incentives for apprenticeship programs to foster practical

skills , subsidized certification opportunities for continuous upskilling ,increased awareness and promotion of job opportunities .

Emerging trends in vocational training : The vocational training industry in developed nations is witnessing changes to deal with present challenges .

Internet based training: The recent pandemic has seen the growth of online vocational training programs, enabling larger access to training opportunities.

Branding: Building a strong brand equity improves institutional visibility, recognition, trust and preferences.

School-Industry initiatives: Industrial collaboration with educational institutes has been providing a diverse pool of talented individuals with job oriented training.

6.3 Implications

This study is aimed at achieving the following results;

Creation of talent pool along with formal training institutes , namely to churn out skilled candidates with a "look ahead " approach.

Reduce employee attrition with the implementation of suggestions outlined in this research.

Increase proximity between industry and academic institutions , to reduce gap between academic curriculum and the industrial practices.

Facilitate the creation of job oriented courses to meet present and future demands.

Certification of courses to add validity , standard and wide acceptability to the courses learnt.

Create a system of regular feedback and upskilling process especially through placement cells of institutes and human resources departments of organisations in addition to adaptation to new technologies to improve quality, reduce costs and increase productivity.

6.4 Recommendations for Future Research

The key areas that were felt essential for future research are Skill development in industrial fabrication and mental health , Skill development in industrial fabrication and world class manufacturing practices, Skill development in industrial fabrication and a rewarding career and Skill development in industrial fabrication and financial management .

Skill development in industrial fabrication and mental health

During the course of our research , we advocated giving importance to the employee " Soft skills " which will be beneficial to their mental health and overall well-being . For example . communication skills time management, stress management , conflict management etc help in dealing with the demands of the job more effectively . Bundle studies indicate that employee mental health and well-being in a demanding, constantly changing, work environment requires focus over and above salaries , bonus , perks to deliver a profound impact on the workforce. The constant pressure has been a result of working from home , connected during personal time, job insecurities etc . During the course of our study we observed a recent SHRM (Society for human resource management) study showed that over 60 % employees are working during vacations, and a an estimated 40% feel guilty for taking time off . This constant " Plugged on" state can lead to a complete breakdown or loss of motivation. Building the necessary skills ,supports mental health and improves self-image .

The broad areas covered under Bundle studies can be categorised in brief as under : Communications kills**:** Crisp and simple communication buildstrust, avoids

misunderstandings and communication gaps. It can minimize frustration which is a major stressor. Time Management: Inability to prioritize work leads to defeatist tendencies and also causes anxiousness . Tools are available to help create a sense of control over the workload. Stress Management**:** The ability to manage stress is important. Simple techniques such as team work , setting ground rules , being mindful and identifying what causes stress help , setting boundaries help maintain a healthy work-life balance.Building Resilience**:** This deals with development of a "never give up " attitude and ability to bounce back from failures

By focussing on soft skills development, we are making an investment in the future of the organization.

The process according to Bundle , comprises of the following steps :

Step 1. Check Skill Gaps: We look at considering the specific needs of different verticals and roles of people therein . For instance, sales dept. may need to look at effective communication and negotiation skills , while a project management team might need a focus on time management , scheduling and delegation.

Step 2. Program selection: Once we understand skill gaps, we choose the appropriate programs. Learning styles of your employees is studied viz whether they prefer instructor led programs , online modules, or a hybrid approach .

Step 3. Make learning an interesting and rejuvenating : We look at the active participation of employees thru games , puzzles , team activities , role ply etc ..

Step 4. Measuring Progress : No program is complete without a feedback system. An effective two way communication has to be established for measuring the program effectiveness and address the pain areas.

Step 5. Create a learning organisation: Learning has no limits . Employees can be encouraged to do self help exercises and identify areas of excellence they wish to pursue . Finally , rewarding those who take initiatives and encourage knowledge sharing and peer- to-peer learning within the organization should be encouraged.

Skill development in industrial fabrication and world class manufacturing

Enterprise Resource Planning (ERP), Quality Management Systems (QMS), Computerized Maintenance Management Systems (CMMS), as well as Artificial Intelligence (AI) etc are used to study manufacturing data , supporting manufacturers to strengthen their business . It is critical for these systems to be implemented on the shopfloor , and other line operations During the course of our research , we came across the Augmentir software package which we found closest in linking skill development and world class manufacturing .

The salient drivers of the study are outlined below ;

Safety: This involves the organisational policies and safety rules , regulations & procedures. Safety training is part of the work culture .

Cost Control : This involves identifying and reducing costs throughout the various manufacturing stages through analysis and formulation of strategies to achieve set targets.

Improvement as a culture : The definition of improvement covers not only the processes, but also the tools, machinery and technology used in the manufacturing

Ownership : Owner ship maintenance involves empowering employees to take full accountability of the maintenance of plant and machinery . This has been useful in

minimising downtime and economising the maintenance expenditure. .

Quality assurance : The term is self-explanatory . Customer satisfaction cannot be compromised.

Layout and Material Flow: Plant layout and material flow are pivotal for achieving growth and sustainable output and reducing wastage .

Special purpose machinery : Successful manufacturing organisations prefer made to order machinery to improve efficiency. The major advantage is the addressal of process constraints at the design stage.

Human Resource Development: This involves providing training and development opportunities, promoting a culture of continuous improvement, and empowering employees to identify and solve problems.

Clean living conditions : This covers manufacturing excellence keeping in view our environment clean and pollution free .

Skill development in industrial fabrication and a rewarding career

A career in industrial fabrication can also be rewarding, for a skilled metal processing work force . The fast growing infrastructural development in the country offers jobs that can pay well and also provide opportunities to work in a wide range of projects . As already mentioned , industries with the highest levels of employment include building construction, ship-building, structural engineering , capital goods manufacture and operations , transportation and various other areas mentioned in our research . The ares of skill enhancement that result in a rewarding career are identified as under ;

Production and Assembly : Production processes require continuous improvement in order to remain competitive . Investment into new technologies , make or buy decisions , resource allocation and man management form important pillars in this area.

Quality Control : Implementation of quality assessment and measuring tools have been practiced in the industry . This filed also is continuously upgrading itself and acquiring this knowledge and ensuring its successful implementation is resulting in superlative organisational performance.

Maintenance and Repair : Professionals in maintenance and repair are responsible for uptime of the plant and machineries. A strong technical aptitude with troubleshooting abilities form the backbone of an industry.

Supply Chain and Logistics : Implementation of re-ordering levels , JIT * (Just in time) parts management , and creating timely material availability , inventory control and favourable credit terms are just few of the major activities that contribute towards organisational efficiency and profitability. Supply chain management is a powerful activity and requires extremely competent people to handle the same.

Skill development in industrial fabrication and financial management

We outline the reasons ,why an understanding finance provides a significant edge in the steel fabrication segment . There is a significant impact towards adding a professional touch to any given skillset . We look at the tangible areas of knowledge gain as under ;

Risk management : A thorough knowledge of manufacturing processes allows professionals to identify the risks and weak links . Financial knowledge is crucial in assessing a company's ability to operate under duress and emergency situations.

Asset value: Shopfloor plant and machineries are valued as fixed assets in the company balance sheet and financial performance. Financial skills help linking their present and future efficiency, lifespan analysis , present the viability of retrofits , reconditioning etc for an accurate valuation enabling the managements to take correct decisions.

Dissection : Manufacturing expertise can help identify optimization areas . Shop personnel trained in financial concepts can spot inefficiencies in production, material wastage points and opportunities for mechanisation or automation.

This analysis is important for identifying cost-saving measures , improve yield and thus , increase profit margins Drivers: Exposure to financial concepts enable shopfloor personnel to analyse their direct contribution to the company's bottom line . By connecting the existing capabilities to their future potential via new technologies , the ability to multiply the operational output we create drivers for future growth prospects.

For effective development of financial insights among skilled manufacturing teams we need to keep in mind that manufacturing professionals don't need to become specialist accountancy experts . Exposure to the basics and its corelation to day to day activity is essential The suggested ways to acquire financial insights are ;

Departmental Orientation : It's advisable to spend short periods of time in the accounts and finance departments and interact with operating staff . Seeing the procedures provides a clear understanding .

Reading and internal discourses : Progressive organisations subscribe reliable publications and reports that cover basic accounting principles , how to read balance sheets etc and organise regular short lectures by finance and accounting team members to educate the manufacturing personnel on the impact of their activity on the company performance .

External Courses and Workshops: Short courses on finance for non-finance professionals help sharpen the commercial acumen . Finance skills aren't just for accountants or finance graduates . Manufacturing professionals who understand finance concepts possess a strategic advantage. They make better-informed decisions, spot hidden efficiencies, and gain a comprehensive view of a company's true potential.

The National Skill Development Corporation (NSDC) stated that the Indian vocational education and training market is valued at USD 6.1 billion in 2020 and is projected to grow at a CAGR of 10.8% during the period of 2021–2025, reaching a market size of USD 10 billion by 2025. We also looked briefly at the vocational training market size in China . The vocational training industry in China is projected to reach USD 120 billion by 2025. The growth of this industry presents significant opportunities for training providers, educational institutions, and investors to contribute to the development of a skilled and adaptable workforce that can meet the ever growing demands of China's fast growing economy.Our research on this subject will be incomplete without studying the skill development based vocational training system in China. We contacted an established industrialist Mr of vocational education consists of education in vocational schools and vocational training.

Vocational education in China is provided at three levels: junior , senior and tertiary levels. The level of specialisation depends upon are of interest and strength areas. The duration of these courses can be anywhere between 5 to 10 years.

6.5 Conclusion

Our study is influenced by an accurate feedback received from 80 respondents comprising active industrialists, staff, workmen, machinery manufacturers and teachers of vocational training institutes. The conclusions drawn are in line with the summary, implications and recommendations for future research. The study is also one of its kind and the first initiative to address a very important process such as Thermal cutting and its role involved in enhancing national infrastructure development and progress. It is indeed difficult to envisage as to why this kind of study has not been taken up till now. Being witness to the infrastructure boom in India between 2004 to 2008 , the growth in sales of CNC thermal cutting machines (gas and plasma) reached 800 machines annually compared to maximum 50 machines before 2003 . The supply of machines was a huge challenge and fulfilled by direct imports from China. Today laser cutting is slowly replacing other processes and our industry is buying over 2000 machines every year . The requirement to examine skills in this area is of prime importance and to consequentially create talent pools to manage the machines . We ve noticed that cutting steel is the first operation in steel fabrication which means that an industry will cease to produce output if CNC thermal cutting is ignored. Since it is the first study conducted in this field, it was also felt that there are areas requiring attention for future research, few of them have been identified and mentioned. It will be our sincere effort to educate various relevant entities across the country about this research, its benefits and help in creating opportunities in different national zones thus, reducing large manpower migrations to fulfil the high-pressure infrastructure growth demands. With the fast development, Computer Numerically Controlled (CNC) thermal cutting machines have become the heart of industrial production, which vastly improve productivity , economics and quality . Our study highlights that attracting the new-generation youth to engineering courses coupled with detailed exposure to CNC machines , programming etc has its own challenges . Locating and employing the right candidate to impart this knowledge can be a major challenge . It is essential to go deeper and find out what can create interest among people to choose this profession . Once the root cause is identified , it should be addressed. The broad considerations towards skilling initiatives are outlined for reference . Additionally , we focussed on reducing the gap between supply and demand of skill-sets . In our case we are referring mainly to CNC thermal cutting . We expect that , increased skills will lead to increased income levels and efficiencies created therein will lead to cost competitiveness. We have immense scope for specialization , thus building national capabilities which are valued not just locally but also globally . Indian workforce have to deliver global quality with local manufacturing and compete with global workforces. There is an urgent requirement of widening the content of available skill development programmes to meet present and future challenges. Finally our goal is to achieve creation of competencies and not just educational degrees , create adaptability to adjust to changing technologies, strengthen strong public-private alliances and envision “self-financing” models for long term sustainability.

We have emphasized the need to raise the number of women in the skilled work-force .Social factors relating to gender discrimination have been pointed out in detail. Additionally , the lower level of status consideration with respect to vocational training in the Indian society has been highlighted. Apart from social factors , we have highlighted the importance of " soft skills " among the important skills needed while critiquing the research topic. These include communication , conflict management , stress management and interpersonal skills . We have also touched the importance of adequate addressal of mental health quality among the work-force. Modern day work pressures lead to psychological damage and these need to be managed. In order to make a successful career it has been recommended to expose the work-force to data management and world class practices such as JIT , ERP and TQM etc. These skills are meant to enhance career prospects . We have also emphasized on the exposure to AI , IOT , automation and cybernetics based knowledge development at a secondary or tertiary level in order to keep pace with the global developments. We introduced the concept of " Servitization " which means to add manufacturing processes that have synergy to CNC thermal cutting to enable an organization to offer additional value added products and services. Another important area we covered is attrition and ways of curbing the same. We have recommended some methods viz job rotation , provide training resources , benefits to family members like subsidy in education and enforce a feedback monitoring system to track wellness etc which can be used in modern day industry to strengthen the attrition reduction . When we say that training on machinery , process , software etc are essential skill sets , its extremely important to address the points outlined above as **"next to essential"** or peripheral skills that will enhance the organisational foundation and performance. Our survey helped identify the industrially fertile zones of India suitable for investment today and discussed the strong reasons for the same in detail . This is a key link to infrastructure developmental and felt essential to highlight . More opportunity means more jobs , value for skills and better renumeration.

Our research pointed out that vocational training and industry participation in developing CNC Thermal cutting skills are yet to develop a synergy . The government of India has taken several initiatives in this regard however , the effect of the same is not reflected by our primary research . The PMKVY (Pradhan Mantri Kaushal Vikas Yojana) scheme implemented in 2020 promises to provide on-the-job training, industry partnerships, and aligning courses with industrial needs. Pradhan Mantri Kaushal Vikas Yojana (PMKVY) is a prime initiative of the Ministry of Skill Development and Entrepreneurship (MSDE) implemented by National Skill Development Corporation (NSDC). The aim is to provide a valid and acceptable skill certification. This will enable the young Indian work-force to take up industry specific vocational training that will help them in securing suitable employment. It is suggested that CNC Thermal cutting technologies and suitable capex to supplement the same have to be procured and courses on STT basis (Short term training) may be imparted. A key section of candidates must also include the uneducated and school / college dropouts . A major advantage being that these training centres can also impart training in soft skills, entrepreneurship, financial and digital education. On the successful completion of the programs , candidates can be provided placement assistance by the centres.

The scheme also recognises people with experience under the RPL (with prior learning experience or skills are assessed and certified under the Recognition of prior learning). It becomes evident that such candidates are encouraged to address their skill gaps and further opt to learn soft skills and basic management principles. The centres are also open towards considering specialised or non-standard skills development activity .

During the course of our research , we evaluated the status of industry investment in vocational institutes. Industries are suggested to consider their involvement in the form of financial assistance as well as providing machinery and equipments to the respective training institutes . In addition , they can also " train the trainers " and provide hands on the training to prospective candidates .

We further conclude that our research content covers a broad range of topics , which may also be applicable to operations other than CNC Thermal cutting. We covered the Indian geographical distribution of types of industries which connect towards the national infrastructure development. During our survey , we classifed sex , age groups , locations , types of industry , salaries , training institutions etc. The survey resulted in valuable findings which have been deeply critiqued along with supporting data and references. Vocational institutions operating with industry plus government based funding such as TREAT in south India was closely studied. Ministry of micro , small and medium enterprises (MSME) cluster scheme is yet another initiative towards public private partnership (PPP) which is mentioned in our research . Women in CNC thermal cutting machine operations in companies like SEDL , north of India and other skill areas viz. Elgi in south of India are also covered . When we compare this with the west and countries like China we are far behind . We have also added the comparison between vocational training in countries like China and India . Pain areas in industrial belts such as "poaching " of employees and possible solutions have been recommended. We examined the 36 focus sectors identified by the National skill development corporation . A brief template for future research such as career development in steel processing / fabrication , mental fitness , world class manufacturing and basic knowledge of finance management are identified. Our research also covers a technology module and clearly shows the role of CNC thermal cutting operations as a backbone of steel fabrication organisations who process steel for infrastructure development . Additionally , we classified the steel structurals into pre-engineered buildings (PEB)and heavy structures . These 2 cover industrial sheds , warehouses , petrol pumps , railway stations , railway bridges , flyovers , high storey buildings , shipbuilding and offshore rigs etc. CNC thermal cutting is not only used to process steel plates , buy also pipes , channels , H beams , flats , angles , billets , bars etc . The range is wide and the process is indispensable.

We have covered three main processes in CNC thermal cutting namely , Gas cutting , Plasma cutting and Laser cutting.

Needless to say , there is a strong emphasis of creating large talent pools to cater to the growing demands of specialised skills. We have also given importance to safety in the working environment .We have additionally interviewed Mr Sanjoy Sarkar and Mr Utkarsh Landekar (Thermal cutting systems professionals) who were instrumental in setting up skill development facilities in India They were also kind enough to share the curriculum they

prescribed for these facilities . The interviews and their supporting documents have been recorded. The information gathered is multi- dimensional and extremely useful for national , international development . All put together , this research is unique and one of its kind. The emphasis on examining CNC thermal cutting skills and its impact on infrastructure development is pivotal. We hope that this research will encourage Indian as well as global professionals to address new areas of research with recommendations for excellence in this domain .

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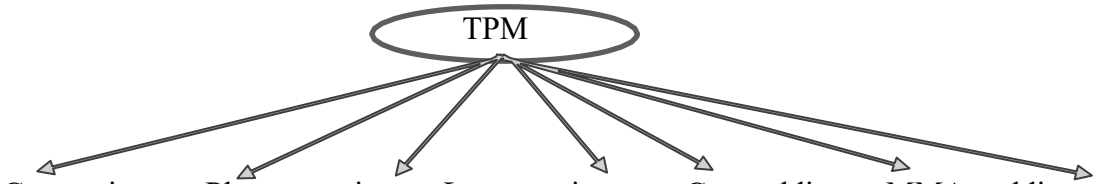
CHAPTER 7
THERMAL CUTTING TECHNOLOGIES

7.1 Introduction

Our study on CNC thermal cutting and its impact on national infrastructure is incomplete without presenting basic knowledge on what comprises CNC thermal cutting solutions. Thermal cutting processes have existed since the 19 th century and epitomised by the simple oxy-acetylene process and as per available data Mr Adolf Messer in 1898 in Germany was among the (Lesczenski , 2018) people who pioneered this process. . The process was further used for cutting steel in 1903 by French Edmond Fouché and Charles Picard developed oxygen-acetylene welding in 1903 by using pure oxygen to produce a chemical exothermic reaction which burnt steel (Henderson ,2020).

Fig 7.1 Thermal processesing of metals (TPM)



Source: SOLAS

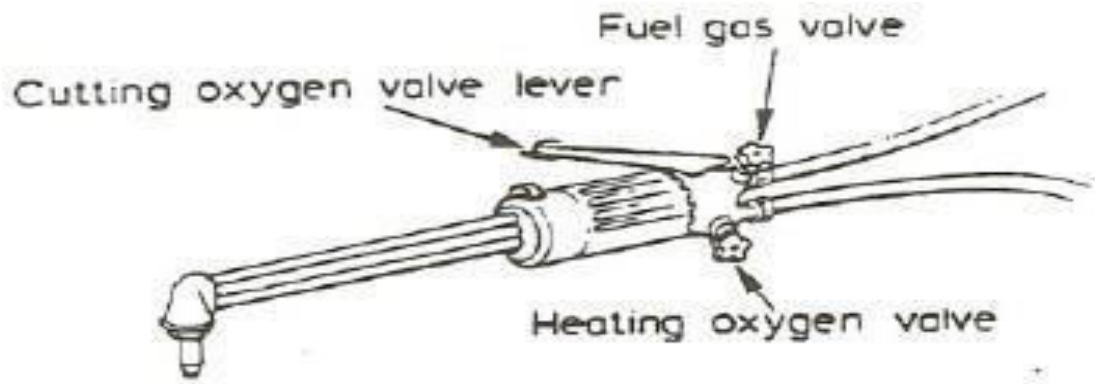
Figure 7.1 explains the thermal material processing methods . Thermal cutting has evolved from the basic oxy acetylene (gas) cutting to the latest laser cutting in present times.

7.2 Gas cutting process & equipment

Of all the methods used for material removal in the fabrication industry, the gas - cutting process plays a prominent part in the preparation of carbon-steel plate material for fabrication related processes. The thicknesses of material is not a limitation different shape or contours can be cut. Metal shears, guillotines cannot be designed to cut shapes, sizes and various thicknessess hence this process is an advantage .gen burning and the cutting happens through a chemical exothermic process (Solas ,2014). Purity of gases play important role in the quality and productivity as in any chemical reaction. Figure 2 shows a typical gas-cutting torch. Inlets

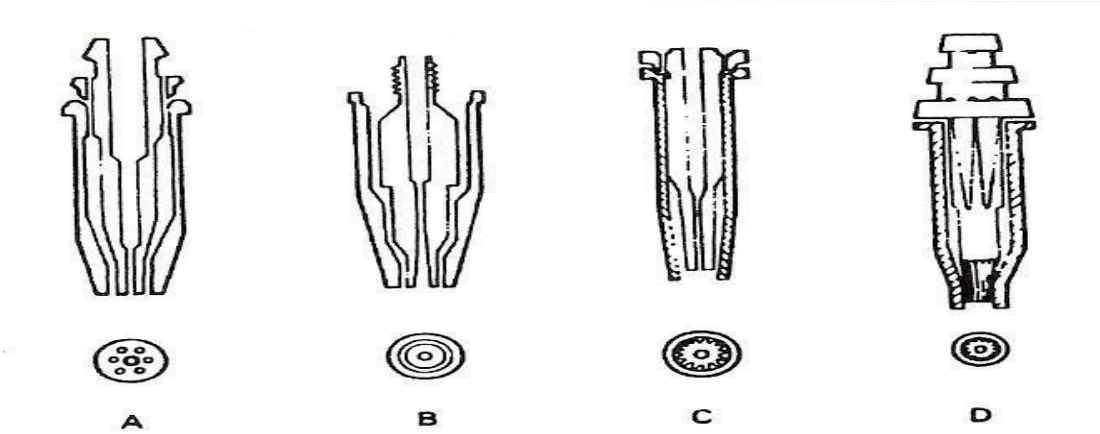
are provided for fuel gas and oxygen .The output is received via nozzzles (refer figure 3) . The nozzle design as shown changes with the type of fuel gases used. Also the nozzle orifice is provided with respect to the volume of gas required for burning. This corresponds to the thickness of the jobs to be cut.

Fig 7.2 Typical gas cutting torch



Source: SOLAS

Fig 7.3 Gas cutting nozzles

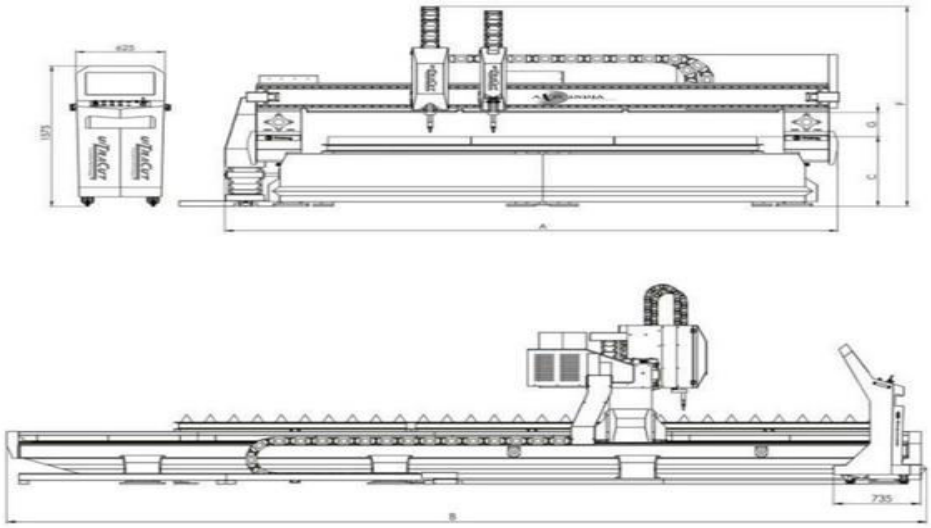


Source : SOLAS

- Single-piece ACETYLENE cutting nozzle
- Double-piece ACETYLENE cutting nozzle
- Double -piece METHANE nozzle
- Double-piece LPG nozzle – parallel bore, pre-heat slots, long skirt.

The working principles defined above were further improvised and mechanization was introduced to improve quality and productivity with safety related features (ref figure 4)

Fig 7.4 CNC gas cutting machine



Source: Proarc Proarc welding and cutting systems , Pune

The major advantages of this process are:

1. Costs less
2. No limitations on cutting thicknesses
3. Multiple torch cutting possible at minimum additional prices.
4. Low on maintenance
5. Consumables costa are low
6. Power consumption is low

The disadvantages are:

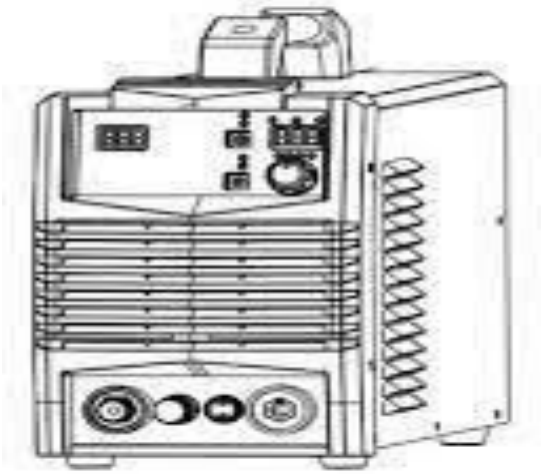
1. Safety is important
2. Can cut only Carbon steels and Titanium. Cannot be used fo Stainless steel and Non-Ferrous metal cutting.
3. Slow process

This process continues to be used today as there are applications like high thickness carbon steel plate cutting , which can be done practically only by gas cutting .

7.3 Plasma cutting process and equipment

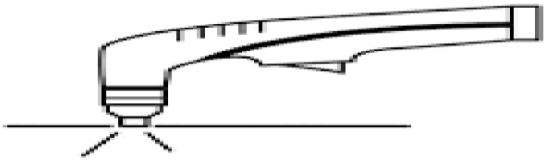
There are three fundamental forms of matter – solid, liquid, and gas. Plasma is the fourth state of matter. Plasma is formed by ionising gases using heat input till they becomes electrically conductive (Woodward, 2020) . This enables it to cut any metal. Plasma process can cut all electrically conductive materials electro-physically. Advanced systems may include CNC control for precision, parametric control and flexibility of operations. This technology is widely used in in the fabrication industry.

Fig 7.5 Plasma cutting power supply



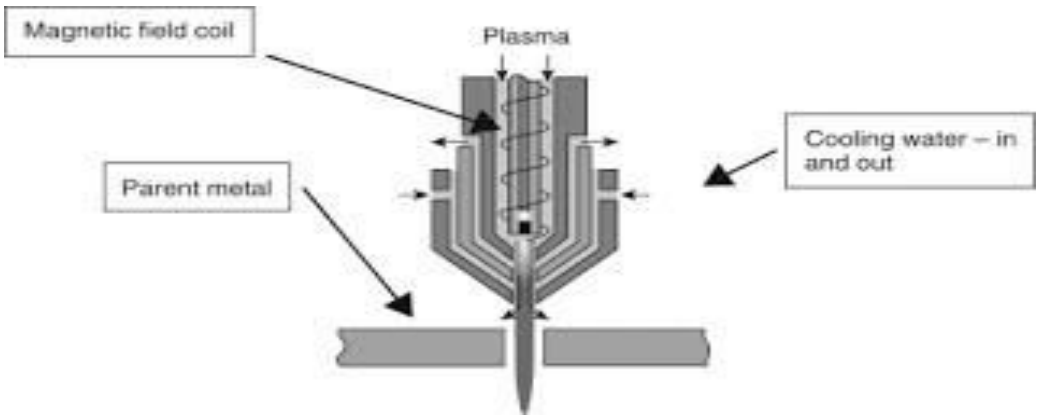
Source: Proarc welding and cutting systems, Pune India

Fig 7.6 Plasma cutting torch



Source: Proarc welding and cutting systems, Pune

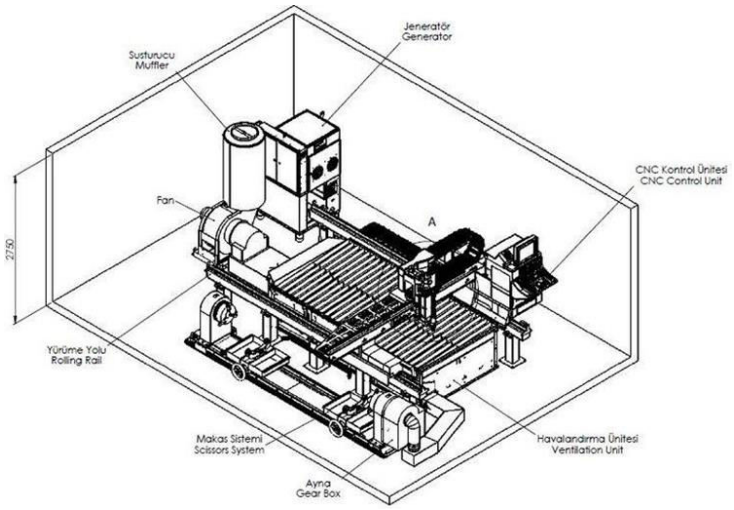
Fig 7.7 Plasma cutting process



Source: Proarc welding and cutting systems, Pune India

Figure 5 depicts the plasma power source, which produces the electric power needed to ionize the gases. Figure 6 shows the plasma torch, which will be held by an operator and directed at job that requires to be cut. Figure 7 shows the process of ionization taking place inside a plasma torch.

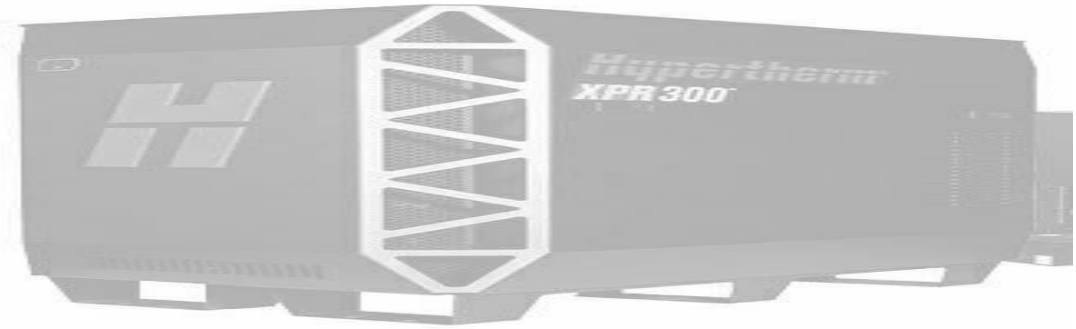
Fig 7.8 CNC Plasma cutting system installation



Source: Ajan CNC, Turkey

Till the end of of the 21 st century Plasma cutting is primarily used for cutting Stainless steels and Non Ferrous metals. Deeper research towards improving process efficiency, productivity and precision resulted in the Oxygen plasma process (Hypertherm Inc , USA). Research done by companies like Hypertherm , USA showed that 70 % of the thermal cutting was required for Carbon steel plates below 25 mm thickness. The economic boom in early 21 st century demanded a process which is fast, economical and avoid post cutting processes. The Oxygen plasma was further improved and high precision oxygen plasma systems were introduced (Ref figure 8). This was a revolution in cutting steels. Where a gas cutting system wud cut 150 mtrs per shift , the new plasma systems cud deliver five times higher output (Source : Proarc welding & cutting systems , Pune , India).

Fig 7.9 Precision plasma system



Source : Hypertherm USA

Advantages of the plasma process :

1. High cutting speeds
2. Clean cutting surface
3. Reduced post-cutting process
4. Lower cutting costs

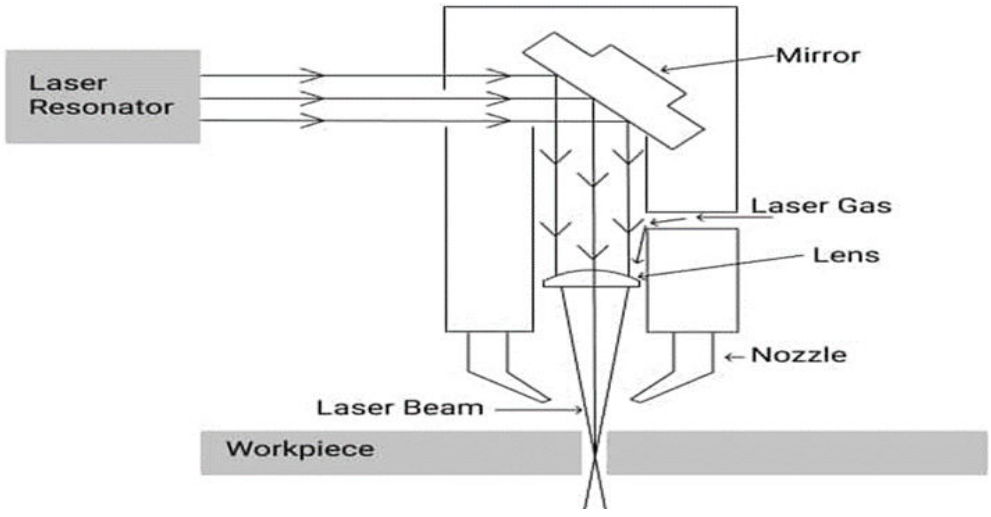
Disdvantages of the process :

1. Air Pollution
2. Higher initial investment
3. Higher operator skill requiremnets
4. Strict adherence to process guidelines
5. Noise pollution
6. Harmful light radiation
7. Higher maintenence requirements

7.3 Laser cutting process

LASER is acronym for Light Amplification by Stimulated Emission and Radiation. As the name suggests, it is a thermal process using light at the primary source of energy. They form an alternate source of energy, which now finds extensive use in metal and non-metal processing (TWI, 2020). Metal processing includes heating, welding and cutting processes. Controlled lasers provide precise, environment friendly, aesthetic and highly productive solutions. Figure 9 shows the working principle which effectively increase light power and provide fine focus , both essential to perform a metal cutting operation.

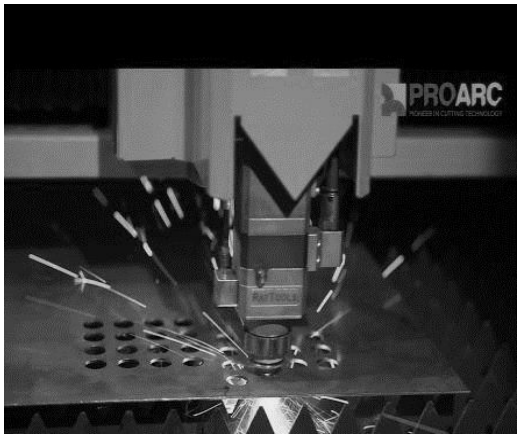
Fig 7.10 Laser cutting principle



Source: Proarc welding & cutting systems, Pune

A modern machine is depcted in figure 10 and figure 11 . The machine is completely enclosed and compact . One can see what the machien looks like from inside in figure 11

Fig 7.11 and Fig 7.12 Modern laser cutting machine



Source: Proarc welding and Cutting systems, Pune

The process was first pioneered in 1965. The last five decades has seen improvements in the technology and performance. Today, the most popular process is Fibre laser technology (Amada, Japan).

The advantages are:

1. High cutting speeds
2. Precision cutting
3. Nil post cutting processes
4. Easy to operate
5. Lowest cutting costs

Major disadvantages being:

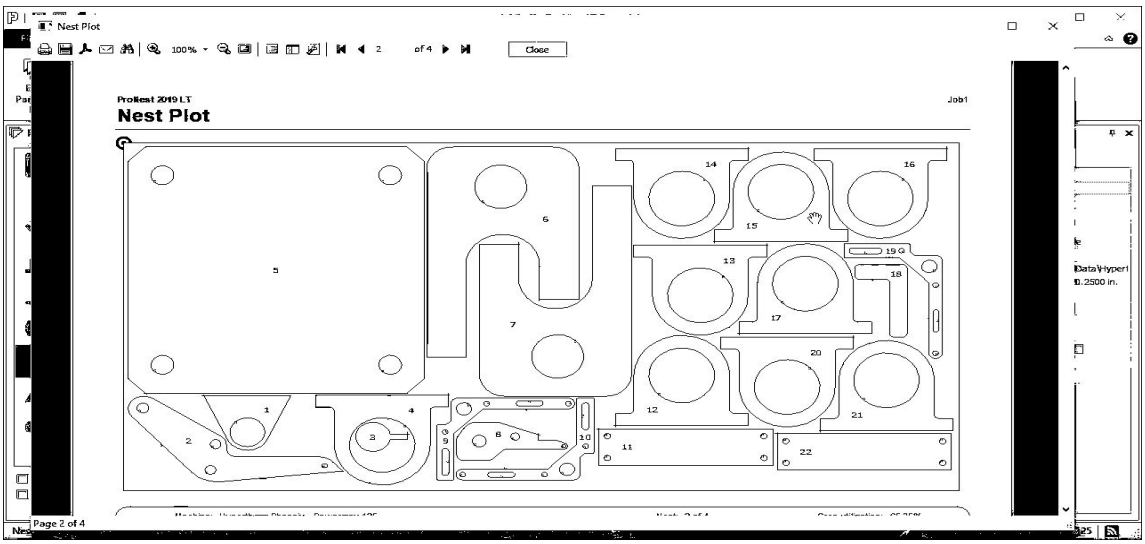
1. Cutting thicknesses not exceeding 25 mm
2. Routine maintenance of machines is a must
3. Demands clean, dust free shop floor working conditions.

Fibre lasers are fast replacing plasma-cutting applications (Proarc, Pune).

Nesting

CNC Thermal cutting is carried out on steel and non-ferrous plates. It's extremely important that parts are cut from a mother plate with minimum wastage. This is facilitated by an offline programming systems and called Nesting software (Sigma nest, USA). Nesting is a mathematical algorithm which evaluates a cutting plan and relates parts to be cut effectively with available raw material with minimal scrap.The programs also allow enhancement of process such as direction of cutting , tool-path , sequence of cutting and communicating with the stored part program CAD files. Project and Product based nesting is another feature (Sigma nest , USA) which helps the process of raw material planning and cost control. Figure 12 shows a typical nested file output. Parts have been placed in a mother steel plate with minimum scrap. Nesting is used in all the three thermal cutting processes described above.

Fig 7.13 Typical nested pattern



Source Pronest – Hypertherm

7.5 Infrastructure based manufacturing

Infrastructural-based manufacturing steps have already been outlined. . We notice that plate-cutting operation is a key operation without which the entire manufacturing process comes to a standstill. We expand these steps and outline a broad spectrum of processeses involved in an infrastructure based project which includes key operations like Procurement of steel, Plate cutting using Gas /Plasma/Laser process through nesting software for optimized use of plate area , H-beam welding on automatic welding machines using submerged arc welding or metal inert gas welding process ,Fabrication for fitments like end plates, stiffeners and connections plates ,Cleaning the surface for finishing, painting etc ,slitting HR coils for cold forming operations to make roll formed sections ,pipe based fabrication Angles, flats, channel processing ,Procuring and assigning required matching fasteners, torquing for connections ,Organizing bought out accessories with supply chain management ,Quality control tests & inspection; and matching with project wise Bill of quantities as given by the engineering department ,Third party approvals, inspections ,Site erection, commissioning , Prove-out ,Handover
and Warranty , Guarantee commitments , maintenance contracts .

***

APPENDIX A SURVEY COVER LETTER

Dear Sir,

We are conducting a research survey to identify the constraints with respect skill development in the area of CNC gas, plasma and Laser cutting area. Kindly click on link below and fill up the form and submit. We will compile zone wise data and make recommendations to Govt of India to pay attention to the subject in focus. Your valuable feedback is eagerly awaited.

Regards

A V Mohan

APPENDIX B INFORMED CONSENT

Title of Study: Examination of the Skills for Facilitating CNC Thermal Cutting Operations to Meet the Infrastructure Demand in India

Purpose: the purpose of this survey is to gather insights on the skills, education, availability related to CNC thermal cutting technologies, and the challenges faced in retaining and recruiting skilled workers in this field.

Participation: Your participation in this survey is voluntary. You may choose not to answer any question or withdraw from the survey at any time without consequence.

Confidentiality: All responses will be kept confidential and used solely for the purpose of this study. Individual responses will not be identifiable in any published results.

Risk and Benefits: There are no anticipated risks associated with participating in this survey. Your input will contribute valuable information to help address the skills gap and improve training and employment practices in the CNC thermal cutting industry.

Consent: By participating in this survey, you consent to the use of your responses for research purposes.

Thank you for your time and participation.

APPENDIX C INTERVIEW GUIDE

Interview Guide: Examination of Skills for Facilitating CNC Thermal Cutting Operations

Introduction:

1. **Greeting:** Introduce yourself and explain the purpose of the interview.
2. **Confidentiality:** Assure the respondent that their responses will remain confidential and used solely for research purposes.

General Information:

1. **Name of Organization/Institution:** (Optional)
2. **Designation:**

Demographics:

1. **Age Group:**
2. **Gender:**
3. **Location of Workplace:**
4. **Industry Type:**
5. **Size of Organization:**
6. **Role/Work Description:**

Skills and Education:

1. **Skill Availability:** Rate the availability of skilled manpower for CNC thermal cutting.
2. **Education Level:** Rate the education level of employees/students related to CNC thermal cutting.
3. **General Manpower:** Rate the availability of general manpower in your region.

Employee Retention:

1. **Retention Rate:** Rate your ability to retain CNC cutting machine operators.

Employee Availability:

1. **Replacement Ease:** Rate how easy it is to replace CNC cutting machine operators.

Educational Institutions:

1. **Vocation Training:** Rate the involvement of educational institutions in CNC thermal cutting technologies.
2. **Student Engagement:** Rate how often students choose CNC thermal cutting as a specialization.
3. **Institution Facilities:** Rate the adequacy of machinery and funding in educational institutions for CNC training.

Employee Attrition:

1. **Attrition Reasons:** Rate the frequency of various reasons for employee attrition in CNC thermal cutting.

Age Groups:

1. **Shopfloor Workmen:** Rate the prevalence of different age groups opting for shopfloor work in CNC thermal cutting.
2. **Supervisory Positions:** Rate the prevalence of different age groups opting for supervisory roles in CNC thermal cutting.

Recruitment Methods:

1. **Recruitment Methods:** Rate the effectiveness of different methods used to recruit CNC thermal cutting employees.

Conclusion:

1. **Final Thoughts:** Ask if the respondent has any additional comments or insights regarding CNC thermal cutting operations.

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SURVEY QUESTIONARE: [Please tick any one option best suited to describe the situation]

1. Name of Organization/ Institution [Optional] …

2. Designation …

3. What is your age group?
a) 21 to 30
b) 30 to 40
c) 40 to 50
d) 50 to 60

4. What is your gender
a) Male

b) Female

5. Please specify the location of your workplace in India
a) East
b) West
c) North
d) South
e) Central

6. What type of industry is your workplace in?
a) Fabrication
b) Machining
c) Vocational institute
d) Trading
e) Site contractor

7. What is the size of your organization?
a) 5 to 25 employees
b) 25 to 50 employees
c) 50 to 100 employees
d) 100 to 500 employees
e) 500 to 2000 employees
8. What type of activity best describes your role or work?
a) Manufacturer
b) Education
c) Software
d) Marketing
e) Finance

9. On the scale 1 to 5, please rate the following with					
Skill , Education and availability related to CNC Thermal cutting (CNC gas, plasma & laser cutting) .	1 Very poor	2 Poor	3 Fair	4 Good	5 Very good
The availability of skilled manpower in your sector					
Education level of employees, peers, or students in your environment,					
Availability of general manpower in the region					

10. On the scale 1 to 5, please rate the following with					
Employee retention related to CNC Thermal cutting	1 Never	2 Rarely	3 Sometimes	4 Often	5 Always
Are you able to retain CNC gas,					

	plasma and laser cutting machine operators?					

11. On the scale 1 to 5, please rate the following with					
Employee availability related to CNC Thermal cutting	1	2	3	4	5
	Very Difficult	Difficult	Moderate	Easy	Very easy
Is it easy to replace the CNC gas, plasma and laser cutting machine operators					

12. On the scale 1 to 5, please rate the following with					
Educational Institutions & their roles related to CNC thermal cutting	1	2	3	4	5
	Never	Rarely	Sometimes	Often	Always
Do institutes provide Thermal cutting technologies (CNC Gas, Plasma or Laser cutting) as a vocation ?					
Do students choose Thermal cutting as a vocation, specialisation in the institutes.					
Are institutes equipped with necessary machines and software to teach practical CNC Thermal cutting ?					
Do vocational schools guarantee employment for CNC thermal cutting related jobs?					
Do vocational schools receive any funding from the industry to start specific courses for CNC Thermal cutting technologies					
Do vocational schools need funds to add CAPEX for CNC thermal cutting eqpt?					
Do vocational schools have trained faculty in the field of CNC Thermal cutting technologies?					
Are there any private initiatives from Industry to develop CNC Thermal cutting technology training facilities					
Do the Engineering colleges, Vocational institutes in your region offer job-oriented courses					

13.On the scale 1 to 5, please rate the following with					
Reasons for employee attrition related to CNC Thermal cutting.	1	2	3	4	5
	Never	Rarely	Sometimes	Often	Always
Health					
Salary , Better offer from competitors					
Family issues					
Location issues					
Language issues					
Hostile environment					

14.On the scale 1 to 5, please rate the following with					
Age group of candidates opting for shopfloor workmen related to CNC thermal cutting.	1	2	3	4	5
	Never	Rarely	Sometimes	Often	Always
20- 30					
30 – 40					
40 – 50					
50 & above					

15. On the scale 1 to 5, please rate the following with					
Methods used to invite prospective employees related to CNC Thermal cutting.	1	2	3	4	5
	Never	Rarely	Sometimes	Often	Always
Candidates approaching themselves					
Referrals					
Newspaper advertisement					
Campus recruitment					
Offer better salary to competitor employees					

INTERVIEW WITH SKILL DEVELOPMENT PROFESSIONAL

1. Brief introduction on your self

I am Sanjoy Sarkar , an Electronics engineer , a Sales Professional with 27 + yrs of experience in Engineering Industry in Welding and, committed to business growth thru' customer delight. Projects cited are those which were executed during my employment with MESSER cutting systems P ltd , Coimbatore India.

2. What motivates u to take up skill development in Thermal cutting and welding ?

A presentation to a engineering college students gathering was the eye opener of the lack for knowledge and knowhow of a very important engg field of welding and cutting due to the education syllabus and curriculum.That motivated me to do further value addition in this field

3. What were the major hurdles you faced ?

Preparation of national occupation standards

Develop competencies for welding and cutting operation

Qualification packs list that needs to be added in sector skill council NSDC

Getting appointment from education minister for representation (Ministry of skill development and entrepreneurship)

4. Where was your first breakthrough and how did u go about addressing it ?

As skill development centre in Malad with welding , cutting booth for thermal cutting along with training and certification was the first breakthru which was inaugurated by Honourable MP of Mumbai North Mr. Gopal Shetty.

5. Also which project was most challenging and why ?

Getting the Project funds approved from government authority is the most challenging phase for skill development

6. What repeat orders you got and from which parts of India ?

1. Government ITI, Ganesh Sisodara, Gujarat
2. Government ITI, Silvasa, UT of Dadra & Nagar Haveli
3. Central Tool room & Training Centre, Bhubaneswar
4. C V Raman College of Engineering, Bhubaneswar 5.Karnataka German Technical Training Institute, Bengaluru
5. Mizoram University Incubation Centre, Aizawl, Mizoram
6. National Institute of Technology, Raipur
7. Indian Institute of Technology, Guwahati
8. Sumant Mulgaonkar Training Institute, ACC, Kymore
9. A K Garg College of Engineering, Ghaziabad
10. Rajendra & Ursula Centre of Excellence, Jaipur
11. PSG College of Engineering, Coimbatore
12. Hindusthan College, Coimbatore
13. Eeshwar College of Engineering, Coimbatore
14. Training Centre – Doosan Bobcat Pvt. Ltd., Chennai
15. Training Centre – G M Shiptech, Chennai
16. Training Centre –HPCL Bangalore
17. Training Centre – Hooghly Cochin Shipyard Limited

7 .How are these initiatives operating now ? Are they offering free or paid courses ?

Initiatives are working but needs Govt focus . Most of them are paid courses

8. What according to you shud be the minimum set up for Thermal cutting training institute?

A workshop with Latest welding and cutting machines along with trainer plus certification plus industry connect for job oppurtunites to successful trainees is required .**What is the minimum level of investment involved?**

Minimum US $ 400000 to 500000

10 Are public-private initiatives towards skill development successful ? Can you share ur experience?

Yes , PPP model is very much successful as it gives confidence to trainees for absorption to industries connected for Jobs , based on their requirements.

11. Did you prescribe a curriculum? Pl share details

Yes, attached.

12. What shud be the future initiatives in this direction ?

Association with NIT 's and German Training Institute , Central Tool room Institute towards skill development initiative is endeavour

13. What in your view is the skill development market size in india and how much has been addressed?

Present market size is around US $ 300 million and expected to grow at a CAGR of 10%. Lot needs to be done to get skilled manpower in engineering sector .

14 Any suggestions to government, industry and educational institutions?

Adding skill sets as per industry requirement should be made mandatory during professional courses so that youth gets inclined and aligned from the beginning itself.

15. What could be the areas of future addressal?

Help the youth thru guidance and career counselling to be proficient to keep pace with changing technologies and gain skill set so that they are employable.

END of interview

TRAINING SYLLABUS FOR 45 DAYS- WELDING & THERMAL CUTTING

TRAINING SYLLABUS FOR 45 DAYS- WELDING & THERMAL CUTTING		
SR NO	**TOPIC FOR THEOREY**	**TOPIC FOR PRACTICAL**
DAY 01	INTRODUCTION OF WELDING	INTRODCTION OF WELDING MACJHNE
DAY 02	INTRODUCTION OF WELDING PROCESS	PRACTICAL DEMO UPON WELDING ACCESSORIES
DAY 03	SAFETY PRECAUTIONS	PRACTICAL-ASSEMBLY OF ACCSSORIES / PRACTICAL-ARC STRIKING ON PLATE with Bead formation 200 X 100 X 10 MM
DAY 04	CLASSIFICATION OF WELDING PROCESS	PRACTICAL-ASSEMBLY OF ACCSSORIES / PRACTICAL-ARC STRIKING ON PLATE with Bead formation 200 X 100 X 10 MM
DAY	CLASSIFICATION OF GMAW WELDING	PRACTICAL-ASSEMBLY OF ACCSSORIES / PRACTICAL-ARC STRIKING ON PLATE with Bead

05	MACHINE	formation 200 X 100 X 10 MM
DAY 06	WELDING TOOLS	OVERLAP-CLADDING ON CARBON STEEL-1G POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 07	WELDING ACCESSSORIES	OVERLAP-CLADDING ON CARBON STEEL-1G POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 08	POLARITY	OVERLAP-CLADDING ON CARBON STEEL-1G POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 09	SAFETY PRECAUTIONS-GMAW WELDING MACHINE	OVERLAP-CLADDING ON CARBON STEEL-1G POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 10	REVISION-EXAM	OVERLAP-CLADDING ON CARBON STEEL-1G POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 11	WELDING TERM AND DEFINATION	OVERLAP-CLADDING ON CARBON STEEL-1G POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 12	WELDING TERM AND DEFINATION	OVERLAP-CLADDING ON CARBON STEEL-2G POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 13	WELDING JOINTS	OVERLAP-CLADDING ON CARBON STEEL-2G POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 14	WEDING JOINTS	OVERLAP-CLADDING ON CARBON STEEL-2G POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 15	WELDING POSITIONS	OVERLAP-CLADDING ON CARBON STEEL-2G POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 16	WELDING POSITIONS	OVERLAP-CLADDING ON CARBON STEEL-2G POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 17	WELD SYMBOLS	OVERLAP-CLADDING ON CARBON STEEL-2G POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 18	WELD SYMBOLS	OVERLAP-CLADDING ON CARBON STEEL-3G - V D / POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY	WELD SYMBOLS	OVERLAP-CLADDING ON CARBON STEEL-3G - V D / POSITION 200 X 100 X 10 MM plate every day one

19		surface per welder
DAY 20	REVISION-EXAM	OVERLAP-CLADDING ON CARBON STEEL-3G - VD / POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 21	DISTORTION	OVERLAP-CLADDING ON CARBON STEEL-3G - VD / POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 22	FILLER WIRE CLASSIFICATION & SPECIFICATION	OVERLAP-CLADDING ON CARBON STEEL-3G - VU / POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 23	WELD DEFECT AND DISCONTINUITY	OVERLAP-CLADDING ON CARBON STEEL-3G - VU / POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 24	WELD DEFECT AND DISCONTINUITY	OVERLAP-CLADDING ON CARBON STEEL-3G - VU / POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 25	WELD DEFECT AND DISCONTINUITY	OVERLAP-CLADDING ON CARBON STEEL-3G - VU / POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 26	REVISION UPON WELDING JOINTS	OVERLAP-CLADDING ON CARBON STEEL-3G - VU / POSITION 200 X 100 X 10 MM plate every day one surface per welder
DAY 27	REVISION UPON WELDING TERM AND DEFINATION	PRACTICAL-FILLET WELD -3MM T JOINT-1F POSITION - Min 10 Jobs per day both side welded total 20 welds
DAY 28	REVISION UPON WELDING POSITIONS	PRACTICAL-FILLET WELD -3MM T JOINT-1F POSITION - Min 10 Jobs per day both side welded total 20 welds
DAY 29	REVISION UPON WELDING SYMBOLS	PRACTICAL-FILLET WELD -3MM T JOINT-1F POSITION - Min 10 Jobs per day both side welded total 20 welds
DAY 30	REVISION-EXAM	PRACTICAL-FILLET WELD -3MM T JOINT-2F POSITION - Min 10 Jobs per day both side welded total 20 welds
DAY 31	BASIC WELD JOINT-DRAWING SKETCH	PRACTICAL-FILLET WELD -3MM T JOINT-2F POSITION - Min 10 Jobs per day both side welded total 20 welds
DAY 32	BASIC WELD JOINT-DRAWING SKETCH	PRACTICAL-FILLET WELD -3MM T JOINT-2F POSITION - Min 10 Jobs per day both side welded total 20 welds
DAY	REVISION UPON WELDING TERM AND	PRACTICAL-FILLET WELD -3MM T JOINT-2F POSITION - Min 10 Jobs per day both side welded total

33	DEFINATION	20 welds
DAY 34	REVISION	PRACTICAL-FILLET WELD -3MM T JOINT-3 F - V D POSITION - Min 10 Jobs per day both side welded total 20 welds
DAY 35	REVISION UPON WELDING ACCESSORIES	PRACTICAL-FILLET WELD -3MM T JOINT-3 F - V D POSITION - Min 10 Jobs per day both side welded total 20 welds
DAY 36	REVISION UPON WELDING PROCESS	PRACTICAL-FILLET WELD -3MM T JOINT-3 F - V D POSITION - Min 10 Jobs per day both side welded total 20 welds
DAY 37	REVISION UPON WELD DEFECT AND DISCONTINUITY	PRACTICAL-FILLET WELD -3MM T JOINT-3 F - V D POSITION - Min 10 Jobs per day both side welded total 20 welds
DAY 38	REVISION UPON WELDING SYMBOLS	PRACTICAL-FILLET WELD -3MM T JOINT-3 F - V U POSITION - Min 10 Jobs per day both side welded total 20 welds
DAY 39	REVISION UPON WELDING SYMBOLS	PRACTICAL-FILLET WELD -3MM T JOINT-3 F - V U POSITION - Min 10 Jobs per day both side welded total 20 welds
DAY 40	REVISION UPON WELD DRAWING SYMBOLS SKETCH	PRACTICAL-FILLET WELD -3MM T JOINT-3 F - V U POSITION - Min 10 Jobs per day both side welded total 20 welds
DAY 41	REVISION UPON WELD DRAWING SYMBOLS SKETCH	PRACTICAL-FILLET WELD -3MM LAP JOINT-2F POSITION - Min 15 Jobs per day both side welded total 30 welds
DAY 42	REVISION UPON-ALL TOPICS	PRACTICAL-FILLET WELD -3MM LAP JOINT-2F POSITION - Min 15 Jobs per day both side welded total 30 welds
DAY 43	GENERAL EXAM-PART 1(WELDING ACCESSORIES)	PRACTICAL-FILLET WELD -3MM LAP JOINT-3 F - V D / POSITION - Min 15 Jobs per day both side welded total 30 welds
DAY 44	GENERAL EXAM-PART 2(WELDING THEOREY)	PRACTICAL-FILLET WELD -3MM LAP JOINT-3 F - V D / POSITION - Min 15 Jobs per day both side welded total 30 welds
DAY 45		PRACTICAL- GROOVE WELD -3MM BUTT JOINT-1G POSITION - Min 15 Jobs per day both side welded total 30 welds

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THERMAL CUTTING SYLLABUS

Index	Syllabus	Thermal Cutting
Chapter 1	**Introduction to Thermal Cutting (XX Hrs)**	Introduction to thermal cutting, Importance of thermal cutting, Finished steel products, Thermal cutting processes, Current industrial scenario, Necessity of the cutting technology
Questionnaire		
Chapter 2	**Introduction to Industrial Gases (XX Hrs)**	Types of industrial gases, Function of these gases, Chemical properties aiding engineering applications, Handling apparatus necessary for gases, Implications of gases on thermal cut quality
Questionnaire		
Chapter 3	**Basic Principles of Oxyfuel Flame Cutting (XX Hrs)**	Introduction to Oxyfuel cutting, Material requirements for the chemical/physical process, Flame cutting possibilities and limitations, Prerequisites for flame cutting, Carbon Equivalent, Alloy compositions and limits for flame cutting, Crack formation prevention, Flame cutting of alloys, Suitable steels for flame cutting
	Questionnaire	
Chapter 4	**Structure of an Oxyfuel Cutting Machine (XX Hrs)**	Functions & applications of Gas Supply, Pressure, Non-Return Valve, Flashback Arrester, Gas Control, Lifter, Critical attributes in gas cutting machines
Questionnaire		
Chapter 5	**Basic Principles of Plasma & Various Power Sources (XX Hrs)**	Theory of plasma, How plasma is generated, Types of power sources, Functions of various gases in plasma, Types of plasma power sources, Critical attributes in plasma cutting
Questionnaire		
Chapter 6	**Structure of a Plasma Cutting Machine (XX Hrs)**	Gas Supply mechanism, Gas Control, Lifter, Effect of machine on job, Software implications on cutting parameters & end result, Critical attributes in plasma cutting machines

	Questionnaire	
Chapter 7	**Introduction to Laser Cutting (XX Hrs)**	Definition of LASER, Applications of Laser in industry, Types of Lasers, Effects of Laser on materials, Critical attributes of Laser cutting
Questionnaire		
Chapter 8	**Health and Safety and Environmental Regulations (XX Hrs)**	Guidelines for working with flammable gases, Safety guidelines when working with Oxygen, Precautions when operating heating flames, machines, and equipment, Personal Protective Equipment for thermal cutting
Questionnaire		
Chapter 9	**How to Define the Cut Quality (XX Hrs)**	Basic introduction to DIN 2310 and EN ISO 9013: 2002, Definitions in the standards, Practical use of the standards
Questionnaire		

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